RISK ASSESSMENT FOR THE IMPORTATION OF BITUMEN FOR ROAD CONSTRUCTION INTO SOUTH AFRICA

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

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ABSTRACT

The purpose of this research project was to identify, assess and model the risks associated with the importation of bitumen into South Africa.

Bitumen has firmly established itself as a product which is not just essential to the construction and maintenance of roads, but also plays a key role as an economic driver of a country. In the years 2012 and 2013, South Africa was faced with a bitumen shortage estimated at 20% of the total production volume of the local industry. This was due to an untimely and unplanned shutdown of a refinery, causing disruption of the road construction industry of South Africa. Due to the unplanned shutdowns in 2012, COLAS – a South African bitumen supplier, imported 3849 metric tons of bitumen into Cape Town. After the operation the South African Bitumen and Tar Association (SABITA) published a document on the "Best practice guide for the procurement and importing of bitumen". This document indicated that, even with risk management being the focal point of many activities and technologies, the risks associated with the importation of bitumen are not well known and documented. Furthermore, limited literature dealing with the international procurement of bitumen is available.

This research project aims to assess and model the procedures and risks involved when importing bitumen into South Africa. The goal is to develop a structured guideline to determine and evaluate risks associated with the importation of bitumen. The guideline contains a procedural outline for the import of bitumen, as well as the identification and assessment of the associated risks. A system approach to the study of the import process was adopted. The system components were analysed and can be classified as physical, organisational and managerial components. The physical components of the system relate to the manufacturing, transporting and storage of bitumen. For the organisational component the different parties involved are discussed. The managerial components discussed are those for the financial, logistical, quality, safety, environmental and contractual management aspects. System related risks were identified by analysing the bitumen import system. Ten major sources of risk were analysed. The relative risk criteria were then determined, from which a risk breakdown structure was developed. Risks were then identified for each of the individual criteria. 75 risks were identified in total, with the risks being identified through literature and semi-structured interviews with industry related parties.

It was established from the semi-structured interviews that intellectual property exists surrounding the quantification of the risks. The decision was made to analyse the risks by means of researching each individual risk, quantifying each based on expert knowledge gained from semi-structured interviews and studying academic literature. An industry professional from Australia was approached to give a second data set of quantified risks. The two data sets were used for the risk analysis. Risk analysis and modelling based on the fuzzy logic methodology was then done. The fuzzy logic methodology was deemed appropriate as the data sets comprised of data which could not be determined in a concise manner. The top 10 most significant risks were identified to be the following, (1) Product does not conform to specifications, (2) Viscosity changes of bitumen during transport, (3) Knowledge inadequacy, (4) Pollution in harbour during unloading, (5) Availability of product from other sources, (6) Unloading delay due to machine failure, (7) Unavailability of sufficient professionals and managers, (8) Inadequate project management controls, (9) Delay in solving contractual issues, and (10) Bad weather on open sea.

It can be concluded that the importation of bitumen is a viable solution to deal with future bitumen shortages in South Africa, but requires expert logistic management and planning for the process to be a success.

OPSOMMING

Hierdie navorsingsprojek behels die ondersoek na, analisering en modelleer van risiko's wat geassosieer word met die invoer van bitumen.

Bitumen, as 'n produk, is gevestig as 'n noodsaaklikheid, nie net vir die konstruksie en onderhoud van paaie nie, maar dit speel ook 'n belangrike rol in die ekonomie van 'n land. Gedurende 2012 en 2013, het Suid-Afrika 'n tekort aan bitumen ondervind wat geskat is op 20% van die land se totale bitumen produksie. Die tekort aan bitumen was weens 'n onbeplande sluiting van 'n raffinadery. As gevolg hiervan, was die totale pad konstruksie industrie van Suid-Afrika ontwrig. Gedurende die periode het COLAS, 'n Suid-Afrikaanse bitumen verspreider, inisiatief geneem, en 3849 metrieke ton bitumen ingevoer. Na afloop van die operasie, het (SABITA) 'n dokument getiteld "Best practice guide for the procurement and importing of bitumen" gepubliseer. Die dokument toon aan dat, alhoewel risiko bestuur in baie bedrywe en tegnologie vertakkings toegepas word, nie baie bekend is oor die risiko's wat geassosieer word met die invoer van bitumen nie. Verder is beperkte literatuur wat die onderwerp van internasionale aankoop van bitumen aanspreek beskikbaar.

Die doel van die navorsingsprojek is om die prosedures en risiko's wat gepaard gaan met die invoer proses van bitumen te analiseer en te modelleer. Daar word beoog om 'n gestruktureerde riglyn dokument vir die invoer van bitumen te ontwikkel. Die riglyn dokument sal 'n prosedurele raamwerk uiteensit vir die invoer proses van bitumen. Hierby sal die geassosieerde risiko's wat geïdentifiseer, en geanaliseer is volledig gedokumenteer word. 'n Sisteem benadering tot die studie van die bitumen invoer proses is vir die doeleindes van die studie-projek toegepas. Die sisteem komponente is geklassifiseer as fisiese, organisatoriese en bestuur komponente. Die fisiese komponent van die stelsel sluit die vervaardiging, vervoer en berging van bitumen in. Die organisatoriese komponente verwys na die verskillende partye wat betrokke is in die stelsel. Die bestuurskomponente verwys na die finansiële, logistieke, gehalte, veiligheid, omgewings en kontraktuele bestuur komponente. Na die ontleding van die bitumen invoer stelsel is die risiko's geïdentifiseer. Tien hoofbronne van risiko's is analiseer. Vir die identifikasie van die relatiewe risiko kriteria, waaruit 'n risiko struktuur uiteensetting ontwikkel is, is 75 risiko's in totaal geïdentifiseer, deur middel van literatuurstudie en semi-gestruktureerde onderhoude met belanghebbende partye.

Deur die onderhoude te voer is daar vasgestel dat intellektuele eiendom bestaan rondom die kwantifisering van die risiko's. Die besluit is geneem om die individuele risiko te kwantifiseer deur middel van navorsing. Die navorsing het bestaan uit semi-gestruktureerde onderhoude en die nagaan van akademiese literatuur. 'n Professionele ingenieur van Australië was genader om 'n tweede stel gekwantifiseerde risiko's daar te stel. Die twee stelle data is gebruik vir risiko-modellering en analise. Risiko-analise en –modellering is gebaseer op die "fuzzy logic" metodologie. Die "fuzzy logic" metode is as geskik geag, omdat die data stelle bestaan het uit nie-eksakte data. Die top 10 mees beduidende risiko's was geidentifiseer om die volgende te wees, (1) Produk voldoen nie aan spesifikasies nie, (2) Viskositeits veranderinge van bitumen tydens vervoer, (3) Kennis ontoereikendheid, (4) Besoedeling tydens die aflaai van die produk, (5) Beskikbaarheid van die produk vanaf ander bronne, (6) Aflaai vertraging weens masjien mislukking, (7) Onbeskikbaarheid van voldoende bestuurders, (8) Onvoldoende projekbestuur beheer, (9) Vertraging in die oplossing van kontraktuele kwessies, en (10) Slegte weer op oop seë.

Daar kan tot die gevolgtrekking gekom word dat die invoer van bitumen 'n werkbare oplossing vir toekomstige bitumen tekorte is, maar dat deskundige logistieke bestuur, en beplanning benodig word om te verseker dat die proses om 'n sukses is.

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LIST OF EQUATIONS

LIST OF ABBREVIATIONS

ABBREVIATION	DESCRIPTION
AHP	Analytical Hierarchy Process
BNP	Best Non-fuzzy Performance
BPAF	Base Price Adjustment Factor
BPI	Bitumen Price Index
CPAP	Contract Price Adjustment Provisions
CPI	Consumer Price Index
CSIR	Counsel for Scientific and Industrial Research
DI	Degree of Impact
FEDAI	Foreign exchange Dealers Association of India
FCO	Full Corporate Offer
FIDIC	Fédération Internationale Des Ingénieurs-Conseils
FOB	Free on Board
ICA	Increased Cost Adjustment
ICC	International Chamber of Commerce
ISGOTT	International Safety Guide for Oil Tankers and Terminals
ISO	International Organisation for Standardization
IT	Information Technology
ITAC	International Trade Administration Commission
ITC	International Trade Centre
LC	Letter of Credit
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
MADM	Multi-Attribute Decision Model
MARPOL	International Convention for the Prevention of Pollution from Ships (Marine Pollution)
MCDM	Multi-Criteria Decision Model
MODM	Multi-Objective Decision Model
MT	Metric Tons
OL	Occurrence Likelihood
P&G	Preliminary and General

PMBOK	Project Management Body of Knowledge
PRAM	Project Risk Analysis and Management
PPI	Producer Price Index
RBS	Risk Breakdown Structure
SABITA	South African Bitumen Association
SANRAL	South African National Roads Agency
SAPIA	South African Petroleum Industry Association
SARS	South African Revenue Service
SGS S.A.	Société Générale de Surveillance South Africa
SOLAS	International Convention for the Safety of Life at Sea
TNPA	Transnet National Ports Authority
TT	Telegraphic Transfer
WBS	Work Breakdown Structure

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter provides an outline of the procedures followed, as well as the thought process followed for the completion of the study. The chapter leads with a background to the research problem from which a problem statement can be concluded. Next, the chapter states the research objectives, research scope and limitations, and the research design and methodology. The chapter concludes with a discussion of the plan of development.

1.2 Background to Research Problem

Bitumen has firmly established itself as a product which is not just essential to constructability and sustainability of roads but also plays a key role as an economic driver of a country (Dobson, Lemphers & Guilbeault, 2013). However, the product is not always readily available as it is derived from a non-renewable resource. As known oil sands resources are depleted and new deposits are discovered, resulting in the fluctuation of bitumen production. This in conjunction with irregular maintenance shut downs of refineries can cause bitumen shortages, resulting in construction companies having to endure economic losses (Ndihokubwayo & Haupt, 2009).

Bitumen can be described as a dark brown to black material which can either be a viscous liquid or a solid, consisting mainly of hydrocarbons and hydrocarbon derivatives (Mathew & Rao, 2006:23.1). The black sticky material is naturally extracted through the fractional distillation of crude oil and is mainly used as a binder in road construction. Scientific evidence indicates that crude oil originates from the remains of organic matter and marine organisms which are deposited with mud and fragments of rock on the ocean bed (Read & Whiteoak, 2003:460). Most (91%) of crude oil consumed in South Africa's is imported, with the rest being locally sourced. The refinement of crude oil, by South African refineries, is to produce petroleum, diesel fuel, paraffin, bitumen and other oil based products (Department of Energy, 2012). The South African oil refineries are Chevron (located in Cape Town), Sapref and Enref (located in Durban) and Natref (located in Sasolburg) (Van Heerden, 2009)(Mathew & Rao, 2006:23.1)

In the years 2012 and 2013, South Africa was faced with a bitumen shortage estimated at 20% of the country's total production volume. This was due to an untimely and unplanned shutdown of a refinery, causing disruption of the complete road construction industry of South Africa (Cokayne, 2013). In this time period a statement was made by South African Petroleum Industry Association's (SAPIA) chairman and chief executive, Christian des Closieres, saying that SAPIA has not yet devised a method for importing bitumen on a timely and reliable basis. He continued by stating that because of this reason South African construction companies would continue to see volatile supply of bitumen (Anderson, 2013). Since 2014 the industry has recovered to producing bitumen on reliable basis. However, the possibility of this type of event recurring in the future however remains real.

Due to the unplanned shutdowns in 2012, COLAS – a South African bitumen supplier, imported 3849 metric tons (MT) of bitumen into Cape Town. The shipment of bitumen was transported from the docks using bitutainers and bitumen specific vehicles. According to the COLAS web-page, the activity was a success, further stating that company feels confident that importing bitumen in the future will become increasingly more important (Colas, 2013). As such, in 2013 SABITA published a document named the "Best practice guide for the procurement and importing of bitumen". The aim of the document was to help corporations with the process of importing bitumen. The document discussed the international sourcing of bitumen, quality assurance of bitumen during the import process, bitumen import logistics and the various health, safety and environmental management procedures. The document did however not discuss the risks involved when importing bitumen. With risk management becoming the focal point of many activities and technologies (Fischhoff, Watson & Hope, 1984:123), combined with limited available literature on the international procurement of bitumen, the research problem was developed.

1.3 Problem Statement

As of 2013 the importation of bitumen, to deal with bitumen shortages in South Africa, represents a new venture for the construction industry in South Africa. It was found that limited literature on the logistic planning and management, as well as risks involved in the importation process was available. With this as background the problem statement for this study was formulated as:

What are the procedures and risks involved when importing bitumen into South Africa?

The term *risk* refers to a variable in a construction project, which if not managed responsibly, could have a negative or positive influence on the desired outcome of the project. The term *procedure* refers to the logistics planning and management. Furthermore, the *import process* refers to the process of importing bitumen, thus from identifying potential sellers to shipment, unloading, storage of the bitumen product and all other managerial and contractual procedures.

1.4 Research Objective

The goal of the research project is to develop a structured guideline for the import of bitumen. The guideline will contain a procedural outline for the import of bitumen, as well as the identification and assessment of the associated risks. The guideline will serve as a foundation for parties attempting to import bitumen into South Africa.

1.4.1 Primary Objective

The primary objective of the study will be to identify and assess the risks involved when importing bitumen into South Africa.

1.4.2 Secondary Research Objectives

To address the primary objective of this study, the following secondary research objectives were formulated:

- To assess the individual elements associated with the bitumen import system.
- To determine the most significant risks by means of a Fuzzy Logic risk assessment.

1.4.3 Research Questions

The study will provide answers to the following research questions:

- Who are the parties involved when importing bitumen?
- What are documentation needed for the import of bitumen?
- What are the procedures to be followed when importing bitumen?
- What are the risks involved when importing bitumen?
- What are the most significant risks when importing bitumen?

1.5 Scope and Limitations of the Study

This section describes the scope and limitations of the study, referring to the objectives of the study. The main focus of the research study is the identification of risks when importing bitumen into South Africa. Some of the risk identified will be specific to South Africa, whereas other risks will be applicable to international procurement in general. Risk identification will be performed for all facets of the import process, and thus will not be specific to just one area of the process.

The risk identification process will be conducted using two methods, the first being a literature study based approach on international procurement of general commodities, general construction project risk management and logistics management. The second will be a review and analysis of information gained from industry professionals who have been involved in the importing of bitumen. All risks identified using literature on international procurement, will be presented to the professionals who have imported bitumen, for consideration. Furthermore, the professionals in question will be from South Africa as well as from Australia. This is done to get a more comprehensive risk identification range, incorporating all risks associated with the process.

The fuzzy logic risk assessment which will be performed, is based on the risk assessment methodology as implemented by Lu, Tu and Chang (2014). An example of the risk assessment methodology can be seen in *Appendix B*. The quantification of the risks for the risk assessment will be performed by to participants, being the researcher himself and one industry professional. The quantification by the analyst will be performed by means of expert judgement, based on referenced academic literature and semi-structured interviews. Each individual risk will be analysed and researched individually, whereupon the risk will be quantified. The semi-structured interviews were not specifically directed at the quantification of risks, as intellectual property surrounding the risks exist (M. Schafer, 2015). As such, data collected during interviews, with reference to certain risks, will be taken into account during the quantification process. All additional risks, not mentioned during interviews, will be researched. Furthermore, the research of the individual risks gives an indication of the approach to be taken by an inexperienced organisation for the import of bitumen. The use of only two quantified data sets is deemed appropriate as the assessment aims to give an estimation of the most significant risks. The participant will be selected based on his experience with the complete bitumen import system, and not just individual components thereof. The participant will not be from South Africa, and also not subject to intellectual property regulations. This will provide better insight as to different risk quantification perspectives perceived by different countries.

1.6 Research Methodology

The term research refers to the logical and systematic method followed in order to find useful information on a particular topic. Only research can lead to the development and progression of a certain scientific or engineering field (Rajasekar, Philominathan & Chinnathambi, 2013). The systematic methodology implemented for this study is divided into two sections, the first of which describes the process to be followed for the study, with the second part of the methodology referring to the data collection methods implemented for the research study.

1.6.1 The Process Methodology

The method followed for the completion of the research objectives associated with the study, is based on the following procedure:

- The obtainment of reference literature data towards the import process of bitumen into South Africa.
- Determining primary data by means of risk identification associated with the importation process of bitumen.
- Collecting secondary data by means of semi-structured interviews with industry professionals for the collection of data towards the procedural obligations when importing bitumen.
- Collecting secondary data by means of semi-structured interviews for the quantification of the risks to be used for the risk assessment.
- Collecting secondary data by means of reference literature for the quantification of the individual risks.

1.6.2 The Data Collection Methodology

The following data collection methods were used in order to gain information towards the study:

- Different peer reviewed articles and academic literature will be used in order to gain a better understanding of the various aspects of the subject material which applies to this study.
- Semi-structured interviews were conducted to gain background to the import industry associated with bitumen, identification of procedural obligations and the identification of risks associated with specific parts of the import process.
- Semi-structured interviews were conducted to quantify the identified risks, which will be used as input data for the risk assessment.
- Different peer reviewed articles and academic literature will be used in order to quantify the individual risks.
- Information gathered will be collated, analysed and cross referenced in order to develop arguments, draw conclusions and make recommendations.

1.7 Plan of Development

The study will be performed using a systematic approach to create a clear path of understanding through the research document, for both researcher and reader. *Figure 1.1* gives a graphical representation of the procedures followed for completion of the research objectives. Each step of the procedure will be discussed in the subsequent sections.

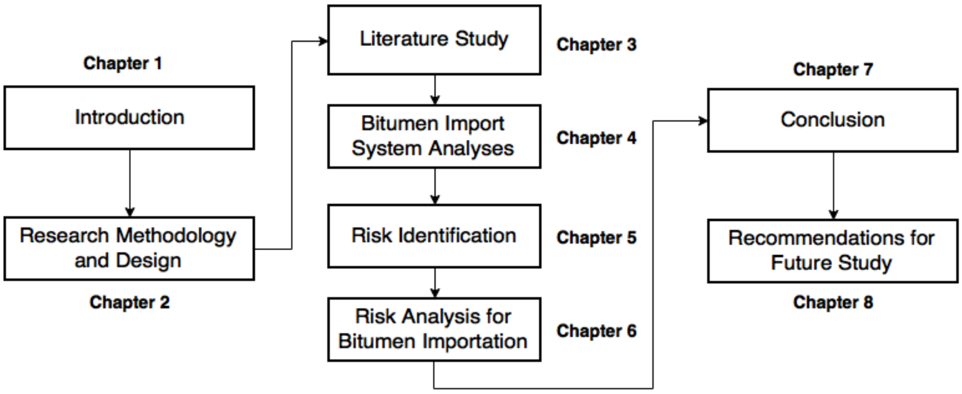

Figure 1.1: Plan of Development

1.7.1 Chapter 1: Introduction

The introductory chapter was introduced to provide background to the research problem, as well defining the problem itself. The chapter also provides a guideline as to the objectives, design and methodology of the study.

1.7.2 Chapter 2: Research Design and Methodology

Chapter 3 will give background to the procedures followed for data collection in terms of literature and interviews. The major topics identified in the literature will be logically structured and analysed. Literature which will be used for the study will be deemed appropriate by means of peer reviews and academic aptness. The chapter will also give a short description of the research objectives, research instruments used, scope and limitations of the study, and ethical considerations being taken into consideration when conducting interviews or collecting data.

1.7.3 Chapter 3: Literature Study

The literature study comprises of questions answered, by means of arguments, structured from academic journals, books, interviews and academically trusted websites. The literature study for this study aims to provide a more complete and detailed background, putting emphasis on the research problem, giving motivation as to why the research is needed and how the problem was identified. A general description of bitumen will be stated. Next, the literature study will discuss the South African and international bitumen industry. Furthermore, the reason for bitumen importation will be discussed, concluding with the necessity of risk management and how it should be performed.

1.7.4 Chapter 4: Bitumen Import System Analysis

Chapter 4 is introduced for the analysis of the bitumen import system. Background to systems theory will be stated as the import system consists of different components and sub-systems. As such, a model, in the form of a flow chart, will be developed. The system components, being physical, organisational and managerial, will be defined separately. Physical components of the system refer to the bitumen product, the development thereof, how it's transported and stored. The organisational components refer to identification, and discussion, of the different parties involved. The managerial component refers to financial, quality, environmental and contractual management of importing bitumen.

1.7.5 Chapter 5: Risk Identification for Bitumen Importation

Chapter 5 will be introduced for the identification of risks associated with the bitumen import process. The identification, as an individual process, will be conducted in a systematic manner. The chapter will commence with background to risk identification criteria, and the use of a Risk Breakdown Structure (RBS). The risk criteria will be identified using academic literature, and will serve as a basis for the RBS. Risks will then be identified for each of the criterion, with the identified risks defined accordingly. A descriptive risk checklist is presented in *Appendix C*.

1.7.6 Chapter 6: Risk Analysis for Bitumen Importation

Chapter 6 will be introduced for the implementation of the fuzzy logic risk assessment. The fuzzy logic risk assessment will be performed in order to determine the most significant risks associated with bitumen importation. The introduction of the Multi-Criteria Decision Model (MCDM) model is due to vagueness in data surrounding import risks, and the quantification thereof. The chapter will provide background information to fuzzy logic and the implementation thereof, state the quantified of the risks, the implementation of the fuzzy logic methodology and finally the ranking of the risks in terms of significance.

1.7.7 Chapter 7: Conclusion

Chapter 7 will provide a summary of the research and will draw closing arguments from this, stating whether or not the research objectives had been reached.

1.7.8 Chapter 8: Recommendations for Further Study

Chapter 8 will provide recommendations for future studies. The studies will be based on information gathered throughout the course of the study, which falls outside the scope of the research project.

CHAPTER 2

RESEARCH METHODOLOGY AND DESIGN

2.1 Introduction

This chapter provides a short overview of the research assumptions made for this study. The chapter leads with background to different types of research decisions. The decision structure comprises of a three level hierarchal structure, with the individual levels representing a decisions between basic- and applied research, normal- and revolutionary research, and quantitative- or qualitative research respectively. Next, the research aims and objectives are defined, whereupon the research instruments used for information gathering will be discussed. The instruments are consists of two sources, namely academic literature and semi-structured interviews. Due to the scope and limitations of the study being discussed in *Section 1.5*, it will not be discussed in the current chapter. The chapter will conclude with a discussion of ethical considerations to be taken into account.

2.2 Type of Research

Research can be defined as a systematic manner in which information is gathered to formulate a solution for a specific problem. The information is gathered using different sources, each with a different perspective on a certain aspect of the problem, combining them to formulate a solution which will be able to contribute to existing knowledge in the problem specific field. Only through such research based problem solving is it possible to make progress in a certain field (Rajasekar, Philominathan & Chinnathambi, 2013). When conducting research a foundation has to be prepared, based upon philosophical and scientific assumptions in order to differentiate between valid and invalid research, as well as the selection of the most appropriate research method for the gathering of information associated with the given problem (Thomas, 2010). Research is divided in to two main categories namely basic- and applied research. Selecting either one of the main categories, results in further sub-categories to be selected from. Choosing the type of research best suited for a specific research problem, a decision path has to be selected through all the categories and sub-categories. The following section will discuss the main categories, and sub-categories, used for the study. *Figure 2.1* gives a representation of the research hierarchy.

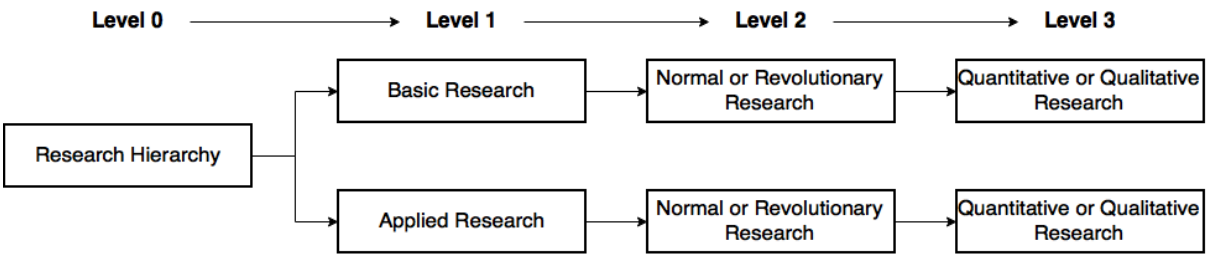

Figure 2.1: Research Hierarchy as adapted from Rajasekar et al. (Rajasekar, Philominathan & Chinnathambi, 2013)

2.2.1 The Use of Applied Research

A decision has to be made between *Basic Research* and *Applied Research*, as seen in *Figure 2.1*. Basic research can be defined as research which investigates the basic principles for a particular events occurrence. The term *Theoretical Research* can also be used to describe basic research. The research type provides the user with a systematic insight into a problem, and delivers scientific or logical conclusions on it. An example of basic research is the study of a natural phenomenon and why it occurs. As such, questions which should indicate in the direction of basic research are as follows: Why is the material behaving in that manner? What are materials comprised of (Rajasekar, Philominathan & Chinnathambi, 2013)?

Applied research can be defined as the solving mechanism used when solving a problem, being that the solving mechanism is based on pre-defined theories and principles. The aim of applied research is to determine the solution for a practical problem which warrants a solution for immediate use (Rajasekar, Philominathan & Chinnathambi, 2013). Applied research does not intend to change or develop theories in order to make them more suitable for a specific problem. From the above stated definitions, it was decided that applied research will be best suited for the study at hand.

Following the choice in research type, a decision has to be made between *Normal-* and *Revolutionary Research*. For the study at hand normal research will be used, as the research study requires will follow a set procedural succeeding. This is known as a paradigm. However, should an event occur where research is forced to digress from the set of procedural rules, it is known as a paradigm shift. During this paradigm shift process revolutionary research is conducted. Should a solution be determined for the problem, it will be ensued by a new paradigm (Rajasekar, Philominathan & Chinnathambi, 2013).

2.2.2 Quantitative and Qualitative Methods Used

The final step of the research hierarchy, as seen in *Figure 2.1*, is the decision between quantitative or qualitative research methods, or using both. The study requires the use of both qualitative and quantitative research. Qualitative research will be used for both the systems analysis and risk identification. Qualitative research can be defined as exploratory research as the research method aims to gain information of the underlying reasons and opinions which are associated with a problem. The method is implemented in order to delve deeper in a certain problem, uncovering trends associated with the problem based on professional knowledge or pre-conceived opinions. The research method is non-numerical, descriptive and applies a certain degree of reasoning. Furthermore, the qualitative data cannot be graphed and is used to give meaning or explanatory information to a problem. The data will be purely descriptive and will give insight into the problem (Rajasekar, Philominathan & Chinnathambi, 2013).

Quantitative research is based on quantities, with result obtained from this type of research being a number or a set of numbers. Quantitative research is numerical, non-descriptive and follows an iterative methodology whereby results are evaluated. The results obtained from this type of research can be displayed using graphs or tables, and is conclusive towards the solving of a specific problem. Quantitative research will be used for the quantification of the risks. As previously stated, the data will be collected using semi-structured interviews, expert judgement and reference literature. The aim of the quantification is to determine the most significant risks (Rajasekar, Philominathan & Chinnathambi, 2013).

2.3 Research Aim and Objectives Descriptions

The research aims and objectives of this study were previously stated in *Chapter 1*. As such the following section will again state the research objectives, giving a description of each.

The Primary Research Objective

The primary objective of the study will be to identify and assess the risks involved when importing bitumen into South Africa.

Description

The aim of the objective is to identify and assess all the risk involved when importing bitumen into South Africa. The risks will be identified by means of academic literature and semi-structured interviews.

Secondary Research Objectives

a) To assess the individual elements associated with the bitumen import system.
b) To determine the most significant risks by means of a Fuzzy Logic risk assessment.

Descriptions

a) The aim of the objective is to provide a complete procedural outline for parties attempting to import bitumen into South Africa. The procedural outline refers to the set of procedures to be followed and implemented in order to import bitumen. The procedures will be identified by assessing the individual elements associated with the bitumen import system.
b) The aim of the objective is to rank the risks in terms of significance, by means of a fuzzy logic risk assessment. The determination of the most significant risks allows organisations to adequate allocate their resources, in terms of mitigation and prevention strategies. The use of the fuzzy logic risk assessment will be explained in *Chapter 6*.

2.4 Research Instruments

Two techniques were used for the collection of qualitative data. The first collection technique is by means of academic literature. The second collection technique refers to semi-structured interviews. Quantitative data will be collected by means of academic literature and semi-structured interviews. The collection techniques will be discussed below.

2.4.1 Academic Literature

Academic literature refers to academic articles published in journals, published books and academically accredited websites. The literature will be used for the identification of risks. The literature which will be used for the identification of risks will be based on international procurement of general commodities, general construction project risk management and logistics management. Literature will be deemed appropriate for academic use based on the following principals: Is the article published in an academic journal; and, has the article been cited in other research studies. When using articles featured on websites, the suitability of the website towards a research project will be based on the following principals: Is the website of academic nature; and, is the author of the article accredited.

2.4.2 Interviews with Industry Professionals

Interviews will be conducted in order to obtain qualitative and quantitative data. The industry professionals will be selected based on their experience in the field of international procurement, with further emphasis being placed on the international procurement of bitumen. Industry professionals were also selected based on their experience towards a specific research question. *Table 2.1* states the name, organisation and information surrounding the professionals interviewed. Summaries of the information gained from the semi-structured interviews are listed in *Appendix A*.

Table 2.1: Interviewee Information

Name	Organisation	Information
Adrian Robinson	Construction Company	Professional Engineer
Danie Erasmus	SANRAL	Engineering Manager: Construction and Maintenance
Gerhard Fourie	SANRAL	Professional Engineer
Johann Fourie	Emmaus Developments Australia	Professional Engineer
Kobus Louw	COLAS	Professional Engineer
Mitch Schafer	COLAS	Bitumen Branch Manager

2.5 Ethical Considerations

The research study investigates the risk factors involved when importing bitumen to South Africa. The study will be viewed as objectively as possible. The objectivity in the research study is needed when analysing the import process as a whole, without insinuating that the importation method of procurement is the only future. It is vital that information gained should be analysed with the intent of seeing it from an outside perspective, being that the two processes should be compared impartially in terms of advantages and disadvantages. The study does not imply any negative accusations towards South African based refineries and is merely examining the risks towards an alternative, should this strategy be needed. Furthermore, before conducting semi-structured interviews with industry professionals, an ethical form must be submitted to the University of Stellenbosch. Upon the approval of the request, it is required that all interviewed professionals signs an agreement, stating that the information gained from the professional may be used for the research report.

2.6 Conclusion

The chapter aimed at giving a structured guideline as to how the study will be performed in terms of research methods used, primary and secondary objectives, research instruments to be used, scope and limitations of the study, and ethical considerations to be taken into account. By shortly summarising the chapter, it was concluded that applied research will be most appropriate for the study at hand. Applied research refers to the solving of a current real world problem, which warrants a solution for immediate use. The research sub-components, as seen in *Figure 2.1*, will be normal research, whereupon qualitative and quantitative research will be introduced. Qualitative research will be used for the system definitions and risk identification. Quantitative research will be introduced for the collection of data towards the risk assessment.

The primary objective of the study is the identification of risks. The secondary research objectives of the study is the development of a procedural guideline document containing the documentation requirements, logistic management outline and descriptive risk checklist, as well as the assessment of risks using a fuzzy logic methodology. Data will be collected by means of literature research and semi-structured interviews with industry professionals. Five industry professionals were interviewed. The professionals were selected based on their experience associated with either a specific research question, or the importation of bitumen. From the interviews it was concluded that the largest concerns surrounding the import of bitumen is the storage of the product, quality assurance of the product, and the management obligations accompanying such a project. It was also noted that from the clients perspective, it was stated that no additional clauses are entered into the construction contract as the risk of sourcing product is the deemed to be the contractor's responsibility. The interviews can be seen in *Appendix A*.

CHAPTER 3

LITERATURE STUDY

3.1 Introduction

Bitumen has firmly established itself as a product which is not just essential to constructability and sustainability of roads but also plays a key role as an economic driver of a country (Dobson, Lemphers & Guilbeault, 2013). According to the *Oxford Dictionary*, bitumen is defined as a residue that is obtained from petroleum distillation which is between black and dark brown of colour, consisting of a viscous mixture of hydrocarbons which is used for roads and roofing (Oxford Dictionaries, 2015). However, the product is not always available, as it is derived from a non-renewable resource. As oil sands are depleted and new oil resources are discovered, the production of bitumen fluctuates. This in conjunction with irregular maintenance shut downs of refineries can cause bitumen shortages, resulting in construction companies having to endure economic losses (Ndihokubwayo & Haupt, 2009).

The chapter aims to report on the South African bitumen industry, where the South African bitumen industry fits in terms of bitumen import and exportation, and how to manage the risk associated with a global industry. When analysing the South African bitumen industry, focus will be placed on the refineries and their associated bitumen production in comparison to the annual bitumen demand in South Africa. The chapter will progress to the international trade of bitumen. The section will report on international trade statistics, in terms of the top importing and exporting countries. The final section of the chapter will look at why risk management is important for international trade. A conceptual depiction of risk is provided as well as the risk drivers and consequences.

For practical purposes the term traditional risk assessment method refers to the risk assessment method as stated in the ISO 31000 document. The traditional risk assessment method will be explained, where emphasis will be placed on risk identification. The importance of risk identification, methods of risk identification, as well as explanations surrounding the implemented methods for this study, will be defined. The use of multi-criteria decision models (MCDM), the application thereof to risk identification and how the appropriate MCDM was selected for the research study, will be stated.

3.2 South African Bitumen Industry

The black sticky material, known as bitumen, is naturally extracted through the fractional distillation of crude oil and is mainly used as a binder in road construction. The use of bitumen in road construction is due to the unique properties of the material. At room temperature bitumen has a density of 1 g/cm^3 and is considered to be soft. However, for low temperatures the material becomes inelastic and at high temperatures the material can be seen to flow like a viscous liquid (Yero & Hainin, 2012:93).

South Africa has four refineries producing bitumen, refined from crude oil. The four refineries are Sapref and Enref (located in Durban), Chevron (located in Cape Town) and Natref (located in Sasolburg). As previously stated, bitumen is a product of crude oil refinement, making up less than 1% of that being refined at the South African refineries (G. Fourie, 2015). The bitumen production of South Africa, as the sum of all four refineries, is between 430- to 450 million litres of bitumen. The average bitumen demand of the South African road construction industry is between 200- and 300 million litres annually (G. Fourie, 2015)(Louw, 2014). A graph displaying the annual production volumes and the annual bitumen demand, in terms of asphalt and seals are displayed in *Figure 3.1* (Louw, 2014). It should also be stated that the total produced volume is not just allocated for the South African road construction industry, as a large portion of the total volume is exported. This is seen in the data presented in the following section, where South Africa is ranked in the top 15 bitumen exporting countries.

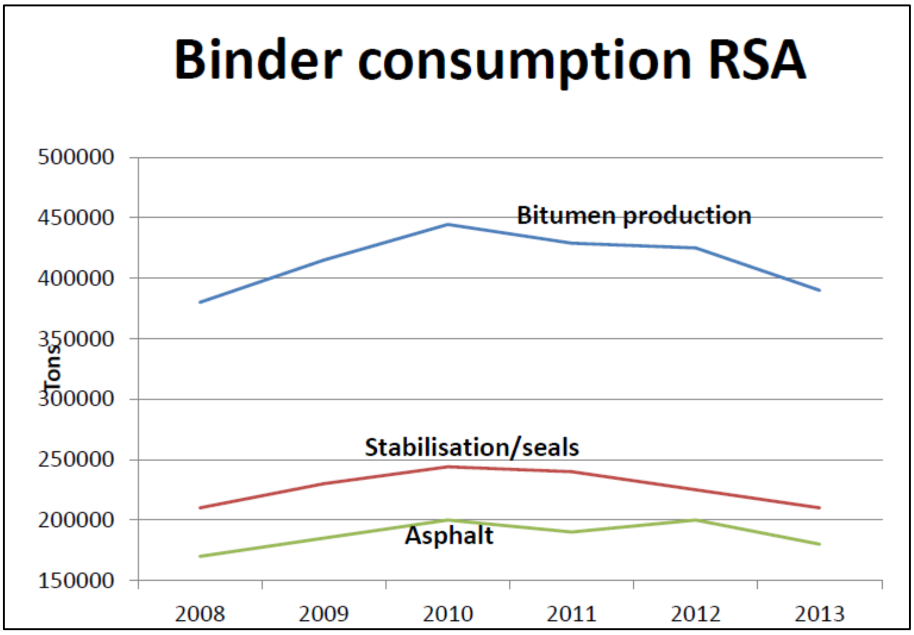

Figure 3.1: Bitumen Production and Demand (Louw, 2014)

In the years 2012 and 2013, South Africa was faced with a bitumen shortage estimated at 20% of the country's total produced volume. This was due to an untimely and unplanned shutdown of a refinery, causing disruption of the whole road construction industry of South Africa (Cokayne, 2013). In this time period a statement was made by SAPIA's chairman and chief executive, Christian des Closieres, saying that SAPIA has not yet worked out a method for importing bitumen on a timely and reliable basis. Because of this reason South African construction companies would continue to see volatile supply of bitumen (Anderson, 2013). Since 2014, the industry has recovered to producing bitumen on reliable basis. Furthermore, it should be stated that the construction industry is informed in terms of the shutdown schedules of refineries. Even with planned shutdowns, South African refineries are more than capable of supplying the demand of the South African construction industry. However, unplanned shutdowns do occur, creating problems for the construction industry, as the demand stays constant when the supply decreases (G. Fourie, 2015).

3.3 International Trade in Bitumen

The international trade in bitumen forms a part of the global economic activity. Bitumen is an essential product for road construction. The following data was obtained from the International Trade Centre (ITC) website. The data is listed under *Product 2715: Bituminous mixtures from natural asphalt, natural and petroleum bitumen*, with the search criteria being *exports*. *Table 3.1* presents the Top 15 bitumen exporting countries, with Malaysia being first and South Africa last. The data obtained is from 2010 to 2014. A graphical representation of the data is shown in *Figure 3.2*. The values are presented in terms U.S. dollar thousands.

Table 3.1: Total Annual Bitumen Exports for the Top 15 Bitumen Exporting Countries (International Trade Centre, 2015)

	2010	2011	2012	2013	2014
Malaysia	4545	6330	37402	7901	951230
Belarus	752	1394	6111	46953	454305
United States of America	124103	101499	121411	108136	113752
Japan	624	763	2271	598	112503
Germany	80965	113958	118786	107850	98130
Canada	53138	57220	45240	50783	57415
Belgium	30817	30052	45275	63729	51802
Russian Federation	7423	5704	17855	25782	50818
Singapore	75249	45269	62156	22663	41070
Netherlands	23599	60737	57867	39537	36725
United Arab Emirates	9175	16446	18175	31379	33220
Austria	30363	25922	32346	29302	31883
Spain	5041	196910	15799	21973	31096
United Kingdome	37366	39779	37082	29023	29097
South Africa	18423	14053	16260	18674	22268
Total Exported	**501583**	**716036**	**634036**	**604283**	**2115314**

Figure 3.2 is a graphical representation of the data as seen in *Table 3.1*.

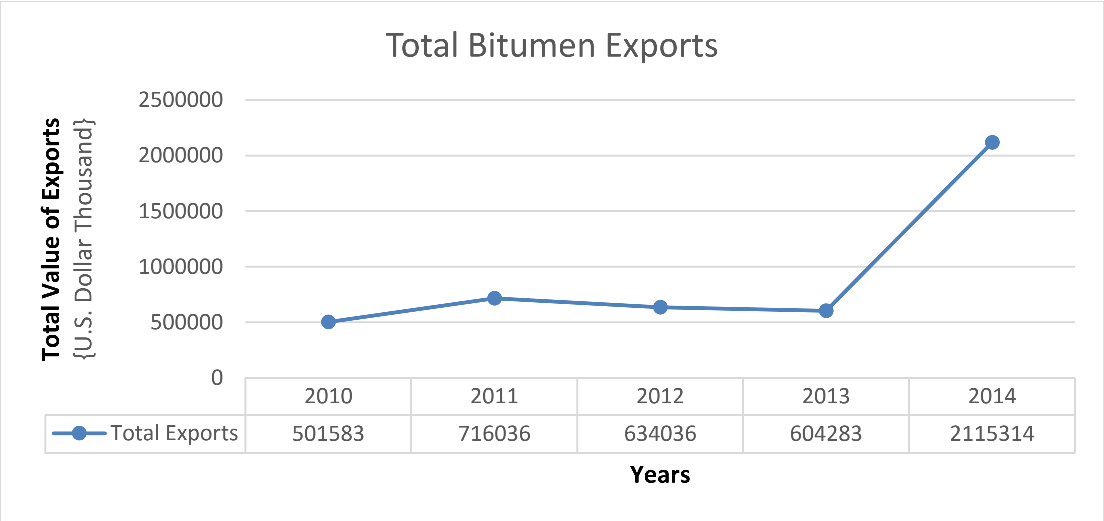

Figure 3.2: Total Bitumen Exports from 2010 to 2014 for Top 15 Countries

The following data was also obtained from the International Trade Centre (ITC) website. It shows the Top 15 bitumen importing countries. The data is listed under *Product 2715: Bituminous mixtures from natural asphalt, natural and petroleum bitumen*, with the search criteria being *imports*. *Table 3.2* presents the Top 15 bitumen importing countries, with China being first and Poland last. The data obtained is from 2010 to 2014. A graphical representation of the data can be seen in *Figure 3.3*. The values are presented in terms U.S. dollar thousands.

Table 3.2: Total Annual Bitumen Imports for the Top 15 Bitumen Importing Countries (International Trade Centre, 2015)

	2010	2011	2012	2013	2014
China	705310	657764	1418379	1017040	2421379
Chile	65941	104835	129476	121500	108694
Netherlands	75142	95702	103793	84798	83486
United States of America	47864	50844	40637	48090	57630
Canada	66841	43266	58874	45865	45471
Panama	1019	2880	67185	37276	42975
Lebanon	60118	41713	61269	35989	33916
United Kingdom	42941	51169	36907	44015	32326
Switzerland	23499	28110	27297	30834	31452
Germany	24189	36260	28888	30540	27752
Austria	15101	15441	17094	22180	25044
Ethiopia	15595	13753	6971	9140	22892
Kazakhstan	2310	34861	7562	5459	21585
France	25245	40635	39974	22197	21551
Poland	9702	13790	14809	14666	17469
Total Imports	1180817	1231023	2059115	1569589	2993622

Figure 3.3 is a graphical representation of the data as seen in *Table 3.2*. As seen in the graph, and as displayed previously, the increase of exports will have a direct influence on the international importing market. This is seen not only in the increasing figures of 2014, for both exports and imports, but also the decrease in both for the 2013.

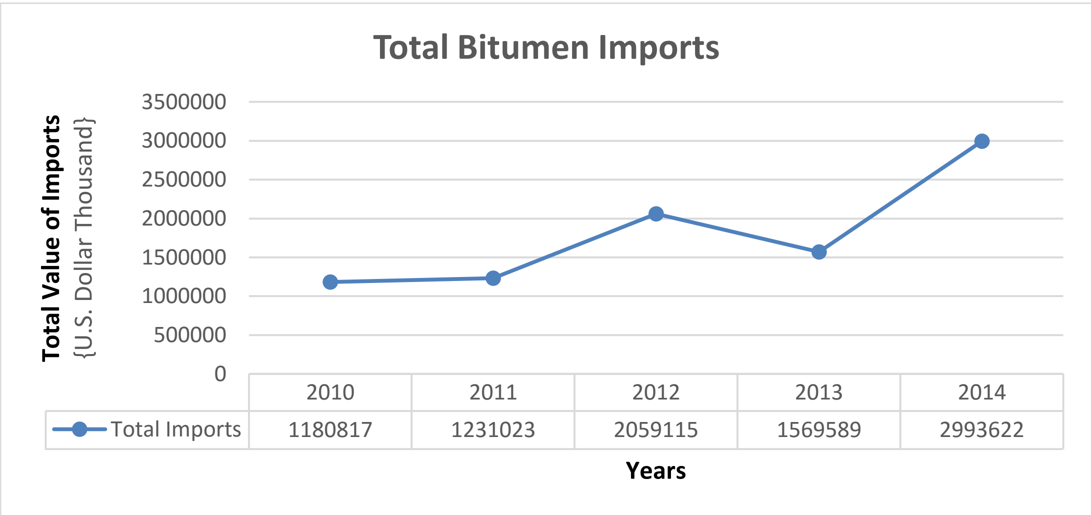

Figure 3.3: Total Bitumen Imports from 2010 to 2014 for Top 15 Countries

The values stated above, for the importation of bitumen, is supported by the global bitumen demand per country. The following data is presented in an Argus media report (Tasker, 2014). *Figure 3.4* shows a pie chart, stating the countries with the largest demand for bitumen. The pie chart was developed in the year 2012, whereupon it is stated that it is expected for 2013 the results will remain similar, after which an increase will be seen for 2014. The demand representation are as follows.

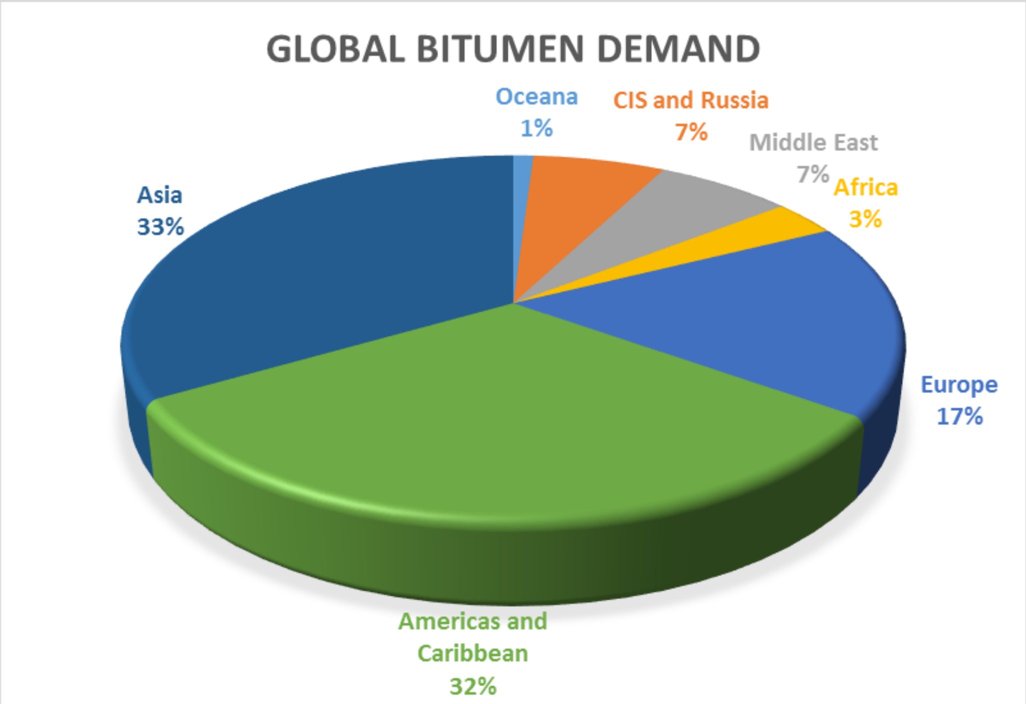

Figure 3.4: Global Bitumen Demand (Tasker, 2014)

3.4 International Trade Risk Management

International procurement strategies requires an integrated approach to risk management (Carter and Ferrin, 2015). The term *integrated* refers to a risk-informed approach to management throughout the whole system (Treasury Board of Canada Secretariat, 2014). By doing so, managers can develop effective and efficient processes to reduce risks to an acceptable level. Purchasing organisation, or importing firms, face risks which are not easily identifiable. Global competition for sources of supply, technological advancements, international currency and interest rate movement are all part of the risk filled environment. Adding political, social, environmental and other factors, creates an unstable risk environment, known as the global economy (Carter and Ferrin, 2015).

Global supply management risk can be defined as an event of action that hinders the importing organisations ability to successfully achieve its sourcing objectives, as well as execute its purchasing strategies. The term global supply management captures the comprehensive focus of the problem. This is done by analysing the entire spectrum of significant, and insignificant, risks which have the possibility to disrupt a purchasing organisations success. In addition, each purchasing organisation will have a set of risks, some generic international trade risks, and some unique to their international procurement strategy (Carter and Ferrin, 2015). A global supply management perspective is thus needed for this study. This perspective will be further discussed in *Chapter 5*, where the associated criteria will be identified and defined.

In order to understand risk management, a common vocabulary has to be developed. The vocabulary should distinguish between risk causes and effects, as well as risk drivers and consequences. The vocabulary should distinguish between risks whose consequences are apparent in seconds or minutes, as opposed to risk consequences which spread over weeks or months, as well as risk which have already materialised as opposed to risk which could potentially happen in the future. The term "risk" is thus difficult to define, as the word encompasses – as seen above – various circumstances (Sodhi & Tang, 2012). In the following section risk will be defined and represented in an illustrative manner. The illustrative depiction aims to separate risk in terms of causes, actual events and consequences. Next, risks will be defined in terms of normal and abnormal risks, risk drivers and risk consequences.

3.4.1 Defining Risk

The process of risk management is the focal point of many activities and technologies. For risk management to be successful, an explicit and widely accepted definition of the term risk is essential. However, the term "risk" is of controversial nature, as the choice of the term's definition can affect the outcome of debates surrounding certain policy matters (Fischhoff, Watson & Hope, 1984:123). In the financial markets, including the import and export industry, defining a risk plays a considerable role as the ever-changing nature of the macro-economic environment is a risk of its own. According to Holton, the financial markets are becoming increasingly more sophisticated in terms of the identification, pricing and mitigation of risks. Tools used for regulation and optimization of these factors are becoming more difficult to manage, inherently posing their own risks. The process of practically applying risk management, in terms of stating risk limits, determining performance-based compensation or penalties, the optimisation of system processes, and capital calculations all depend on the measurement of risks (Holton, 2004:19). As such, it is only justified that in the construction industry, an industry plagued with risk and the consequences thereof, risks are defined in correlation with the nature of the industry.

According to literature, a construction risk is defined in various ways, with every definition concluding that the realisation of a risk having a negative economic effect. According to Akintoye, a risk can be defined as a variable in a construction project, which has to the potential to fluctuate, and if so introduces uncertainty which can have an influence on the quality, schedule and cost of a project (Akintoye & Macleod, 1997:31). According to Eshan, Alam, Mirza and Ishaque, risks are present in all construction projects, being classified more as fate than a choice, as the inherent uncertainty of construction project makes risk inevitable, creating uncertainty as to the quality-, schedule- and cost outcome of a project (Ehsan, Alam, Mirza & Ishaque, 2010). Other definitions supported by Perry and Hayes, state that risk is directly connected to economic loss or gain when involved in the process of construction (Perry & Hayes, 1985:499). When analysing the definitions as presented, it can be concluded that a risk is a variable in a construction project, which if not managed responsibly, could have a negative or positive influence on the desired outcome of the project.

3.4.2 Risk and Risk Management

Risk and risk management can be depicted by using the shape of a butterfly. This conceptual depiction was created by Sodhi and Tang (2012). Sodhi *et al.* (2012) stated that delineation has to be drawn between the elements associated with the risk lifecycle, being from the *risk cause* to the *risk event*, to the *risk impact*. The risk cause is located before the risk event, whilst the risk impact is felt after the risk event. Also, *prevention methods* are before the event, whereas *response efforts* are made afterwards. The butterfly depiction of risk is presented by *Figure 3.5* (Sodhi & Tang, 2012).

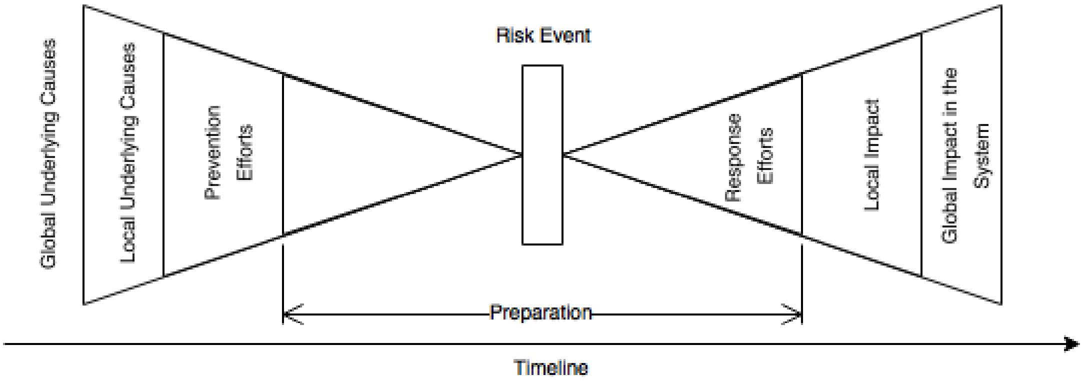

Figure 3.5: Butterfly Depiction of Risk (Sodhi & Tang, 2012)

The body/abdomen of the butterfly, as seen in *Figure 3.5*, represents the risk event. The left wing of the butterfly represents the prevention efforts leading up to the risk event, whereas the right wing represents the response efforts after the event has occurred. The left and right wing can be further extended to include additional causes and impacts. This form of risk depiction has several benefits. The body of the butterfly, being the risk event, separates the causes from the effects, thus providing clarity to the analysts of what the risk is. The associated timeline reports on the prevention, response, and preparation-to-response in time, enabling analysts to plan for any particular risk category. Furthermore, one risk event has the ability to trigger other risk events. The butterfly depiction takes this into consideration. The complete risk event can be seen as a collection of individual depictions, similar to *Figure 3.5*, or as one depiction represented by *Figure 3.6* (Sodhi & Tang, 2012).

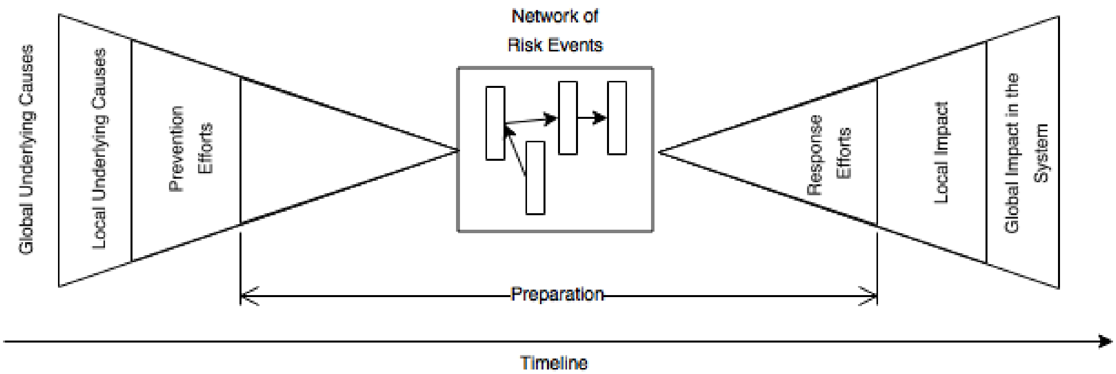

Figure 3.6: Butterfly Risk Depiction for Network of Events (Sodhi & Tang, 2012)

In order to implement prevention and response strategies, as seen in the figures above, requires an adequate risk management system. These types of systems aim to identify, quantify, assess and mitigate risks. Risk management can be performed using various systems and strategies. The different types of systems will be explained in later in this chapter, as well as stating the risk assessment system best suited for the research study.

3.4.3 Normal and Abnormal Risks

When analysing systems, the risks associated can be classified into two categories, being delays and disruptions. The categories are not risk criteria, but instead refers to the nature of the risk itself. The two categories can be renamed into normal and abnormal risks accordingly. By knowing the nature of the risk, analyst can determine a strategy best to deal with such a risk. According to Sodhi (2012), it is crucial that firms dedicate time towards prevention of both types of risks, but emphasis should be placed on normal risks, as they are ever present and constantly realising. Normal and Abnormal risks are defined as the following (Sodhi & Tang, 2012).

Delays (Normal Risks)

Normal risks, or delay associated risk, refer to somewhat expected risks such as price fluctuations, supplier incapability to comply with demands, low quality output, long standing time for authorisation at customs and bad weather.

Disruptions (Abnormal Risks)

Abnormal risks, or disruption associated risks, refer to unexpected failures such as total product loss due to bad weather during shipment, natural disasters, war, labour uprisings and terrorism.

3.4.4 Risk Drivers and Risk Consequences

The occurrence of uncertain events (risks) is trademarked by their consequences. The consequence is dependent on location, having a local- and global influence. The local influence happens as the risk event takes place, whereas the global influence is directly linked to the actions taken by parties after the event has occurred. An example of this being the attack on the World Trade Towers on September 11. From the viewpoint of manufacturing firms, the event was an unforeseen event and a risk none the less. However, the subsequent suspension of air transportation after the event, led to the causing of supply delays, which in effect caused a temporary standstill of the manufacturing sector of America. Local consequence refers to an event impacting a specific location within the system, whereas global consequence refers to an event which impacts the complete system (Sodhi & Tang, 2012).

Every system is designed and created to achieve a set of objectives. Once the objectives are known, a key set of drivers have to be identified, as the drivers are the variables influencing whether or not the objectives will be reached (Alberts & Dorofee, 2009). The risk driver is not the risk itself, but can be defined as a *point of possible occurrence*. A risk driver can further be described as a risk criterion. A risk criterion is an encompassing term used to define an area of concern, from which different risk events might stem. Risk criteria will be discussed in *Chapter 5*. The interaction between risk drivers and consequences is displayed in *Table 3.3* (Sodhi & Tang, 2012).

Table 3.3: Relationship between Risk Drivers and Risk Consequences (Sodhi & Tang, 2012)

		Risk Consequences (Region of possible eventual impact)	
		Local Consequence (Impact to a particular system entity, or particular market)	***Global Consequence*** (Impact to the entire system, or multiple markets)
Risk Drivers (Point of possible occurrence)	***Local Driver*** (Originating at an entity in the system, or particular market)	Local risk stemming from supply or demand situations.	Risks originating in a specific market, from which the consequences eventually impacts the entire system.
	Global Driver (Originating system wide, or through multiple markets)	Global risks that affect a particular system entity.	Global risks which can affect the entire system as a whole.

3.5 Traditional Method of Risk Analysis

The phrase - traditional risk assessment technique - is used to describe the risk assessment technique which incorporates the impact-probability function in conjunction with a risk assessment matrix, ranking the risks before and after the implementation of mitigation strategies. This process provides analysts with a before- and after mitigation representation of the risk priority. The technique is one of the most popular risk assessment techniques and is prescribed by the ISO 31000 and the Project Management Body of Knowledge (PMBOK). The risk assessment procedure follows a systematic approach in assessing risks, as seen in *Figure 3.7*, combining an iterative process in order to gain more knowledge of various types of risks, associated with different construction projects. By doing so, companies have a growing risk database with accurate data, which gives them better insight for future construction projects.

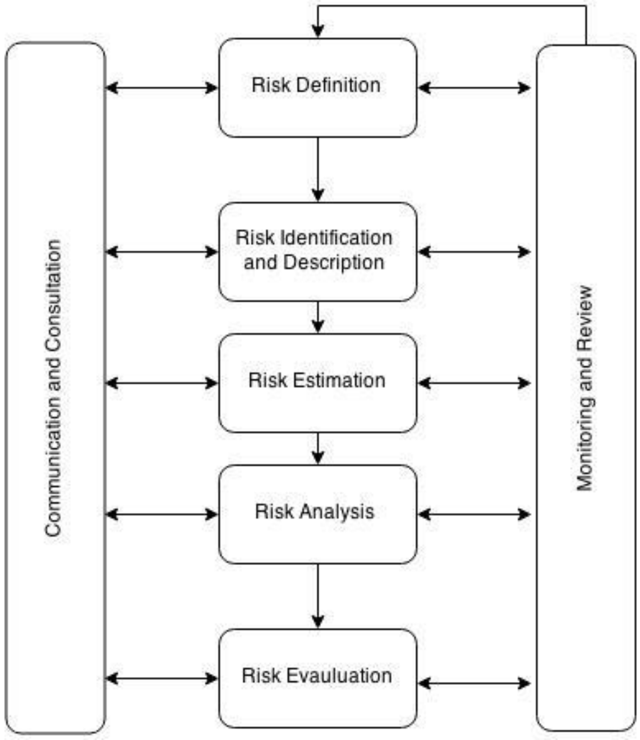

Figure 3.7: Traditional Risk Assessment Procedure (International Organization for Standardization: 31000, 2009)

3.5.1 Risk Definition

As previously stated, a risk is defined in the literature cited, as a variable in a construction project, which if not managed responsibly, could have a negative or positive influence on the desired outcome of the project. This definition is supported by what is stated in the ISO 31000 document. According to the ISO 31000 standards a risk is defined as the effect of an uncertainty on objectives, with the effect being either a positive or negative deviation from that which is expected and stated in the contract document (International Organization for Standardization: 31000, 2009). According to CLUSIF, a non-profit organisation acting as a gathering spot for Information Technology (IT) security professionals to exchange ideas, a risk is made up of three sections, the first being the presence of a threat, the second being an threat based target such as a project schedule or physical asset, and the last being a vulnerability. As such, according to CLUSIF, a risk is defined as a combination between a target, a threat capable of influencing that target and a vulnerability exploited by the threat in order to damage the target (CLUSIF, 2009).

3.5.2 Risk Identification and Description

The aim of risk identification is to identify, to the best of the organisations ability, all relevant risk sources. The term *relevant* refers to all risk sources, being external or internal, global or local risks. As the risks are identified, it is the responsibility of the identifier to give a detailed description of the risks which has been identified. The detailed description should be structured in a manner which is understandable by all members of the project team. Should risks be articulated correctly, it will have a large influence on the assignment of risk ownership, estimating risks, developing effective risk response strategies, identifying the risk causes, and the explaining of the implications of risks. It is recommended that risks should be described using a three-part method, stating the context and sources of uncertainty and impact (RMCapability, 2011).

The project risk analysis and management (PRAM) process is made up of various stages, being risk identification, risk assessment, risk management, risk monitoring and review. From these stages it is acknowledged that the risk identification and assessment stages are deemed the most important, having the largest impact on the accuracy of the risk assessment. The risk identification is mainly based on subjective expert judgements, whether being in the form of literature or through communication. These judgements are the foundation to efficient and effective risk management (Chapman, 1998:333). It is stated by Tchankova (2002) that the initial risk identification process is essential to risk management effectiveness, with non-identified risks becoming un-manageable problems further on in the project. The views of Tchankova (2002) is supported by Perry (1986), Garrido *et al.* (2011) and Chapman (2001). Perry stated that risks should be identified early in the project lifecycle, as the risks themselves acts as constraints on the project. Following this, Perry stated that the identification of risks are of great importance, even if the next stage of the risk assessment procedure is not implemented (Perry, 1986). Garrido *et al.* (2011) stated that many consider the risk identification phase as being the most challenging and relevant phase in the risk assessment process (Garrido, Ruotolo, Ribeiro & Naked, 2011:242). Chapman (2001) stated that risk identification is considered by many to be the most important element of the complete risk assessment process (Chapman, 2001:147).

The way in which risks are identified varies between organisations, but usually includes historical data, surveys, interviews, brainstorming and individual professional knowledge (Tah & Car, 2001:170). The identification of relevant risk sources enables organisations to build risk profiles. These risk profiles refer to a database containing all relevant risks associated with a specific project. According to Dinu (2012), the maintaining of the risk profiles can be deemed as important as the identification itself. Furthermore, it is stated that is no single right way to risk identification. The process of risk identification can be divided into two phases being initial risk identification, and on-going risk identification. Initial risk identification is defined as the start of risk profile for a specific project. On-going risk identification is defined as a developing risk profile, where new risk sources can be added to during the project lifecycle (Dinu, 2012). The risk identification techniques can be further classified into three categories. These categories are (1) identification done solely by the risk analyst, (2) identification by the analyst when interviewing a member of the project team, and (3) the analyst leading the working group (Chapman, 1998:333). *Table 3.4* gives a representation of the identification categories, as presented by Chapman (1998).

Table 3.4: Identification techniques as presented by Chapman (1998)

Risk Category	Process	Support Tools
Identification by Risk Analyst	Expert experience of the analyst Review of project files and literature Review of historical data	Project Lifecycle Checklist
One-to-one Interview	Defence systems management college	Sequence attribute modifications matrix

	Clarke *et al.* (2002)	Decomposable matrices
	Spetler *et al.*	Project Lifecycle Checklist Rating Grid
Working Group led by Analyst	Brainstorming Nominal group technique Delphi technique Synetics Scenario building	Project Lifecycle Checklist

The study requires the implementation of a combination of two categories, being the *Identification by Risk Analyst* and *One-to-one Interview*. The two categories will be explained in more detail in the following sub-sections.

3.5.2.1 Identification by Risk Analyst

The identification of risks for the study will largely be based on academic literature and semi-structured interviews as stated in *Chapter 1*. According to Chapman (1998), the support tools for this method of identification is checklists and a project lifecycle assessment.

3.5.2.1.1 Risk Checklist

Risk checklists refer to the development of a checklist form, stating all risks identified from historical data or academic literature. The checklist is used as a survey, where industry professionals are asked to "check" the risks which are according to them relevant (Chapman, 1998:333)(Dinu, 2012).

3.5.2.1.2 Lifecycle System

Chapman (1998) states that a lifecycle approach can be used as a support tool for risk identification. To get a better indication of what the term lifecycle entails, the concept of lifecycle assessment has to be defined. The term lifecycle assessment (LCA) refers to the systematic approach undertaken to analyse a products complete lifecycle, from the raw material to the point of disposal. This is referred to as the cradle-to-grave perspective. The project lifecycle can however be broken down into various sub-systems namely *Cradle to Grave*, *Gate to Grave*, *Cradle to Gate* and *Gate to Gate*. The lifecycle system to be assessed will be stated and explained in *Chapter 4*. A project lifecycle consists mainly of five stages. The stages are raw material attainment, processing, manufacturing, product life and end of life. Descriptions of the five stages are represented in *Table 3.5* (Williams, 2009).

Table 3.5: Project Lifecycle Stage Description (Williams, 2009)

Stage	Description
Raw Material Attainment	This stage refers to material harvesting as well as the transportation thereof to manufacturing site.
Processing	This stage refers to material processing operations as well as the transportation of materials to production sites.
Manufacturing	This stage refers to the product manufacturing and assembly procedures, as well as packaging, transport and distribution.
Product Life	This stage refers to the energy consumed and emissions emitted during product life, as well as maintenance and reuse of the product.
End of Life	This stage refers to the recycling of the product, or the disposal thereof.

Using a project lifecycle approach, as a support tool for risk identification, holds value. This is seen in the process in which the technique is applied. The technique associated with the lifecycle approach consists of four stages. The four stages are definition and scope, lifecycle inventory (LCI), lifecycle impact assessment (LCIA) and final report. The stages are defined in *Table 3.6* (Williams, 2009).

Table 3.6: Lifecycle Assessment Implementation Technique Stages (Williams, 2009)

Stage	Description
Definition and Scope	This stage of the technique requires the determination of information needs, data precision, data collection methods and data presentation.
Lifecycle Inventory (LCI)	This stage of the technique is completed by means of process diagrams, data collection and data evaluation.
Lifecycle Impact Assessment (LCIA)	This stage of the technique requires the determination of impact categories, their associated weights as well as subsequent results.
Final Report	The stage is completed at the end of the lifecycle assessment. The stage requires that a formal report be developed containing significant data, data evaluation, data interpretations and final conclusions.

In the past few years, researchers have been trying to amalgamate the concepts of risk assessments and lifecycle assessments. Problems however arose as the two assessment techniques require different inputs, and deliver different outputs. Furthermore, the process of risk assessment is classified as a downstream analysis, as the risks are evaluated from identification to the point of consequence and mitigation. The LCA is regarded as being upstream and downstream analysis.

The individual process of risk identification is considered to have no set flow path, with risks being identified for any component of a system, at any given time. This results in a lifecycle approach being helpful towards risk identification, as both are based on a lifecycle approach (Flemström, Carlson & Erixon, 2004).

3.5.2.2 One-to-one Interview

The process of one-to-one interviews, as stated by Chapman (1998), is structured around the methodological approaches of three studies. Not all the studies are readily available, with only Clarke, Pledger and Needler (1990) being available for reference. The documentation provides an overview of how identification of risks through interviews should be conducted. The identification process is divided into two steps. The two steps associated with this form of risk identification is displayed in *Table 3.7* (Clarke, Pledger & Needler, 1990).

Table 3.7: One-to-one Risk Identification Interview Description (Clarke, Pledger & Needler, 1990)

Step	Description
1	The first step requires the determination of the scope of the work. This entails interviewing the core team associated with the project.
2	The second step requires a planned approach to be developed. The planned approach should have the following: • Objective requirements; • Determining who needs to be interviewed; • Schedule of first cycle interviews; • Schedule of follow-up interviews, and • Development of strategic questions for final identification purposes.

3.5.3 Risk Estimation in terms of Probability and Impact

Based on the basic assumptions that accompany the traditional risk analysis technique, risk is usually defined as function of probability and impact of different incident scenarios (Yazdani-Chamzini, 2014:82). The probability- and impact ratings are subjective, being based upon personal knowledge and professional experience. According to Hallikas, Karvonen, Pulkkinen, Veli-Matti and Tuominen, the probability ratings should be assessed from a viewpoint that includes the whole system. Thus, when assessing the probability of a certain event, the organisation should take all additional factors into account, if possible, as each factor has the potential to alter the probability of an event. This being said, the complete opposite applies to the assessment of the impact ratings for risk events. According to Hallikas *et al.*, when analysing risks in terms of impact, the corporation should assess the impact ratings from the viewpoint of the enterprise: what kind of impacts it may face. The reason for this being that, should an event have a negative impact on one company in a system, it may result in a negative-, no- or positive effect for the rest of the companies in that same system. *Tables 3.8* and *3.9* represents the assessment scales with which the risks should be analysed (Hallikas, Karvonen, Pulkkinen, Virolainen & Tuominen, 2004:47).

Table 3.8: Impact Assessment Scale {{100 Hallikas, J. 2004}}

Rank	Subjective Estimation	Description
1	No Impact	Insignificant in terms of the whole company
2	Minor Impact	Single small losses
3	Medium Impact	Causes short-term difficulties
4	Serious Impact	Causes long-term difficulties
5	Catastrophic Impact	Discontinue business

Table 3.9: Probability Assessment Scale (Hallikas, Karvonen, Pulkkinen, Virolainen & Tuominen, 2004:47)

Rank	Subjective Estimation	Description
1	Very Unlikely	Very rare event
2	Improbable	There is indirect evidence of event
3	Moderate	There is direct evidence of event
4	Probable	There is strong direct evidence of event
5	Very Probable	Event recurs frequently

3.5.4 Risk Analysis Procedure

With the risks estimated in terms of probability and impact, the traditional risk analysis progresses to the following step known as *Risk Analysis*, as seen in *Figure 3.7* As previously mentioned, according to the traditional risk analysis technique, risks are usually expressed as function of probability and impact (Yazdani-Chamzini, 2014:82). This correlation can be seen as expressed by *Equation 1*, which shows the risk in terms of the risk score, which is calculated using the formula as presented.

$$Risk\ Score = Probability\ x\ Impact \tag{1}$$

After the risk score for each risk is calculated, a risk matrix is used to determine the output risk level. According to Yazdani-Chamzini, the risk matrix as presented by *Table 3.10* is a strong tool for identifying and eliminating potential failures to improve the level of safety and reliability on site. The method provides analyst with data which can be used to make strategic decisions involving the construction project at hand. The risk score of each individual risk is matched with its corresponding number on the risk matrix. The risk matrix is colour coded to translate the risk score into linguistic terms. The linguistic variables, along with the corresponding colour codes are presented in *Table 3.11*.

Table 3.10 Risk Matrix as a function of Probability and Impact {{99 Yazdani-Chamzini, A. 2014}}

$Risk\ Score = P \times I$		Probability				
		Very Unlikely	Improbable	Moderate	Probable	Very Probable
Impact	No Impact	1	2	3	4	5
	Minor Impact	2	4	6	8	10
	Medium Impact	3	6	9	12	15
	Serious Impact	4	8	12	16	20
	Catastrophic Impact	5	10	15	20	25

Table 3.11: Linguistic terms used for Risk Matrix (Yazdani-Chamzini, 2014:82)

Linguistic Term	Definition	Rating	Colour
Insignificant	Risk is tolerable without any mitigation	(1-4)	
Tolerable	Some partial mitigation may be needed	(5-8)	
Substantial	Mitigation may be needed	(9-12)	
Significant	Mitigation should be implemented to reduce risk	(13-16)	
Intolerable	Mitigation that reduces risk must be implemented	(17-25)	

3.5.5 The Evaluation of Analysed Risks

Risk management is a continuous process that takes place throughout the lifespan of the project. *Figure 3.7* shows that risks should continuously be monitored and assessed in order to identify risks missed previously, or to identify new risks that developed as the project progressed. For each risk that is identified, a mitigation strategy has to be developed in order to decrease the potential impact the risk might have on the project. Risk mitigation involves identifying the range of options for treating the risk, evaluating those options, preparing the risk treatment plans and implementing those plans. It requires the analyst to consider all possible options for the treatment of the risks, selecting the most appropriate method to achieve the desired outcome. Options for treatment need to be in proportion to the significance of the risk, with the cost of treatment being in proportion to the potential benefits of the treatment. The treatment options available for mitigating risks are as follows (Nicholas & Steyn, 2012:366):

- Accepting the risk;
- Avoiding the risk;
- Reducing the risk;
- Transferring the risk;

- Retaining the risk, and
- Financing the risks.

The mitigation process of risks requires the analyst to assess the risks individually, selecting a mitigation strategy for each individual risk. For a risk with a low probability and a low impact, the mitigation strategy can be to accept the risk. For a risk with a high impact rating in conjunction with a high probability, the mitigation strategy of reducing the risk, financing- or transferring the risk might be a more viable solution. Upon completing the mitigation process for all risks, the total risk score can be re-evaluated and re-ranking of the risks can commence if needed. When analysing the risk scores of different projects or even different operations, the data output can further be used, not just to indicate the potential most influential risk, but also for decision making. This being said, it is required of an organisation to continuously monitor all identified risks as well as attempting to identify future risks and risk sources. By doing so, an organisation can prevent future risk realisations and damages, and in the process preventing financial and quality losses (Nicholas & Steyn, 2012:366).

3.6 Applying Multi-Criteria Decision Model (MCDM) to Risk Analysis

The use of Multi-Criteria Decision Making (MCDM) models have increased over the past decades as the models have been implemented for different decision making scenarios, in different fields of work, with older models being upgraded and improved. The MCDM models can be used directly for real world problems, with the increase in technological innovation resulting in the solving of more complex decision making problems, as well as the development of new MCDM models. The experimentation process, involving the use of different MCDM models in combination with one-another, provided a whole new approach to decision analysis (Velasquez & Hester, 2013:56).

3.6.1 Types of Multi-Criteria Decision Models

Multi-Attribute Decision Making is one the most widely used branches of general decision making. The branch is part of a general class of Operational Research models which deal with decision problems within the borders of certain prescribed decision criteria. The complete class of models, of all sorts, are defined under the name of Multi-Criteria Decision Models (MCDM). According to Triantaphyllou, the class known as MCDM models are further divided into Multi-Objective Decision Making (MODM) and Multi-Attribute Decision Making (MADM). MODM models are used for decision problems where the decision space is continuous, thus it does not use a pre-determined set of alternatives. An example of this is mathematical programming with multiple objective functions. As such, MADM models use a pre-determined decision space, using known boundary conditions as well as pre-defined and determined alternatives (Triantaphyllou, Shu, Nieto Sanchez & Ray, 1998:175) (Zanakis, Solomon, Wishart & Dublish, 1998:507).

Many different MCDM models have been developed over the years, each pertaining to a unique set of advantages and disadvantages. Each method has its own characteristics, with the only way to classify them being according to their individual data input. That is, we have deterministic, stochastic and fuzzy MCDM methods. However, combinations of different data inputs sets can occur. The following section will give the identified MCDM methods (Triantaphyllou, Shu, Nieto Sanchez & Ray, 1998:175). The following literature was analysed in order to identify the different

MCDM models: (Velasquez & Hester, 2013:56); (Sehra, Brar & Kaur, 2012:10); (Department for Communities and Local Government, 2009), and (Triantaphyllou, Shu, Nieto Sanchez & Ray, 1998:175).

- Multi-Attribute Utility Theory
- Analytical Hierarchy Process (AHP)
- Fuzzy-Set Theory
- Case-based Reasoning
- Data Envelopment Analysis
- Simple Multi-Attribute Rating Technique
- Goal Programming
- ELECTRE
- PROMETHEE
- Simple Additive Weighing
- Technique for Order of Preference by Similarity to Ideal Solution

3.6.2 Selecting Appropriate Type of Multi-Criteria Decision Model

As previously stated, when selecting a MCDM method to use for a specific analysis requires the identification of the input data set used for the analysis, being stochastic, deterministic or fuzzy. Furthermore, a decision has to be made as to whether a MODM- or MADM model will be used for the analysis. For the research study at hand, the alternatives will be pre-determined, being the identification of the risks, thus a MADM method will be best suited for analysis purposes. The data input sets to be used will be discrete of nature. According to Zanakis *et al.*, many researchers have proposed different methods for decision making problems, describing how decision models could help analyst in choosing between alternatives (Zanakis, Solomon, Wishart & Dublish, 1998:507). However, MCDM methods have been widely criticized for inconsistent output data. According to Schinas, one of the critical issues surrounding the use of MCDM method is justification of the outcome. A study was performed to showcase this inconsistency, where three different MCDM models were used for the same problem, producing three different end results. This being said, Schinas continues to state that this inherent attribute of MCDM models, however impeding the extensive use in daily business, can be surpassed should the right model be selected for a specific problem. The model should be selected based on previous implementations, literature and by means of extensive boundary condition definition (Schinas, 2007).

As stated, for the paper at hand, an MADM model will be used as the proposed analysis will be done using a pre-defined set of variables. When choosing between different MADM models, the input data first has to be analysed stating whether the data is classified as stochastic, deterministic or fuzzy. In the case of a risk analysis, the data can be classified as fuzzy. The term fuzzy, according to Velasquez *et al.*, is used for a set of data which is imprecise and uncertain. When analysing bitumen import risks for South Africa, industry professionals are asked to rate risks based on professional knowledge and experience. As such, different professionals will rank certain risks differently based on their subjective knowledge. The complete set cannot be defined by a single number but rather a range. Such a single number is referred to as a crisp number, being precise and well defined. Furthermore, professionals might not have the knowledge, but make educated guesses based on similar, but not exact, situations. The information gathered in these circumstances will not be deemed as crisp, but rather as vague and imprecise (Velasquez & Hester, 2013:56). In the case of a risk analysis, the advantages outweigh the disadvantages when using a fuzzy based MADM method. When analysing the supplier selection using a MADM methodology, Kahramn, Cebeci and Ulukan stated the advantages supporting the decision to use a fuzzy based methodology. The reasons for their choice can be implemented in selecting a MADM method, especially the fuzzy logic decision making model. The advantages to the model according to Kahramn *et al.* are as follows (Kahraman, Cebeci & Ulukan, 2003:382):

- Fuzzy logic based decision model is able to deal with vague data.
- The fuzzy theory allows for mathematical programming to have an influence to the fuzzy domain.
- Fuzzy data sets have the ability to transform the natural expressions of knowledge on real world problems, which are vague, into quantifiable data.
- Decision makers are more inclined, and comfortable, providing confident inputs based on a range of values than stating crisp values.

According to Chou, Chou and Tzeng, choosing a decision model for a specific problem, addressing all the project variables is a difficult, if not impossible process (Chou, Chou & Tzeng, 2006:1026). This statement was supported by Kahramn *et al.*, as a combination between the Analytical Hierarchy Process (AHP) and fuzzy based methodology was proposed (Kahraman, Cebeci & Ulukan, 2003:382). However, when analysing risk factors associated with the importation process of bitumen, only risk in terms of impact and probability will be taken into account. This, combined with the rankings being based on expert estimations instead of personal experience, creates a domain best managed by a fuzzy based approach, as not many professionals in South Africa have been part of a bitumen import process. By using a fuzzy based approach, the decision model will satisfy all the requirements, as stated by Chou *et al.*, in order for a decision model to be ()a success. These requirements are [1] incorporate the opinions of experts of all levels of a corporate structure, with different levels of experience, [2] incorporating different criteria into one model, [3] the appropriate model flexibility to change weights given to certain criteria, [4] the model should combine quantitative and qualitative decision making, and [5] be easy to use and save time (Chou, Chou & Tzeng, 2006:1026).

3.7 Conclusion

The chapter aimed at analysing the South African bitumen industry, locally and in the international context, whereupon the need of risk management for global practices were discussed. Emphasis was placed on the importance of risk identification and the ways in which it should be conducted. The research done indicated that the South African road construction industry requires between 20- and 30 million litres of bitumen annually, which is much less than the produced value by South African refineries, being between 430- and 450 million litres of bitumen. It was however found that large quantities of the produced bitumen is exported to various international destinations. South Africa ranked in the top 15 bitumen exporting countries. This as a result indicated that the quantity of bitumen allocated to the South African road construction industry covers the demand, even in times of planned shutdowns. In the event of an unplanned shutdown, the demand of the construction industry exceeds the supply. This is where shortages arise.

A global risk management perspective is thus needed for the bitumen industry. This type of perspective analyses both internal, in terms of local and global risks, as well as incorporating external risks. These criteria are further discussed in *Chapter 5*. Furthermore, the way in which risk should depicted, as research indicated, is by means of the butterfly concept. The butterfly concept requires a sound definition of risk, and the terminology associated. After analysing different academic literature and definitions associated, it could be concluded that a risk is a variable in a construction project, which if not managed responsibly, could have a negative or positive influence on the desired outcome of the project. The traditional method of risk analysis was explained, with emphasis being placed on risk identification. This being said, inadequate identification of risks could lead to negative events in a project, resulting in project objectives not being reached. According to various studies, as previously stated, risk identification is considered to be one of the most import components of the risk management process. Chapman (1998) identified various techniques for adequate risk identification. The techniques best suited for the study is *Identification by Risk Analyst* and *One-to-one interviews*. The implementation of both these techniques were implemented as accurately as possible. The use of MCDM's for risk assessment were defined. Different types of MCDM's were stated, whereupon the selection strategy of the appropriate MCDM model for the research study was explained. It was found that due to vague data, being data that is not precise as well as data that is subjective to the professional, that a fuzzy logic methodology will be most appropriate for the research study. The fuzzy logic methodology will satisfy all the requirements as mentioned earlier, ensuring accuracy when performing the risk analysis later in *Chapter 6*.

CHAPTER 4

BITUMEN IMPORT SYSTEM ANALYSIS

4.1 Introduction

The representation, and study, of a system creates the opportunity for improvement (Institute for Healthcare Improvement, 2004). This chapter aims to decompose the bitumen import system analysing the various components thereof. The chapter leads with a short description of systems theory, defining associated concepts and terminology, where after the scope of the import system is defined. The system is then decomposed into its various components, being the physical-, organisational- and managerial components. The physical component of the bitumen import system represents the manufacturing-, transport- and storage elements. The organisational component of the import system is orientated around the parties involved. The managerial component is analysed in terms of financial, logistics, quality, health, safety and environmental management accordingly.

4.2 Background to Systems Theory

Ludwig von Bertalanffy proposed General Systems Theory in 1928. The biologist characterised a system on the ability of nonlinear interaction between components. The result of this being that knowledge of one part of the system gives access to knowledge about another part (Walonick, 1993). Systems can be characterised as physical, biological, social or symbolic, or as a combination of these. A system is also comprised of various sub-systems. Within a system or sub-system, the central variable time plays a substantial role, as it is referent for the concept of dynamics. This dynamic nature of systems can take various forms, namely growth, steady state or decay. This being said, systems are goal orientated, and it is this attribute which characterises changes seen in the state of the system. For every change, feedback is given, which acts as a mechanism, mediating between the system goal and system behaviour (Chen & Stroup, 1993). The study of systems is referred to as systems thinking. Systems thinking according to Senge (1990), as stated by Franks and Waks (2001), is the ability to see something as a whole, being the interrelationships and patterns of change rather than a static snapshot (Frank & Waks, 2001). As such, a systems thinking approach is appropriate for use when analysing the system of bitumen importation. The import system consists of physical-, organisational- and managerial components. The system is complex and crosses different corporate fields, as well as having different subsystems and external influences working in on the system.

4.2.1 Systems Concept and Terminology

Systems are unique by nature, but share common concepts and terminology. These concepts and terminology will be discussed in the following sections.

4.2.1.1 System Structure

As previously stated, a system was defined by Bertalanffy (1928) as a nonlinear interaction between various elements and the environment in which they exist (Walonick, 1993). Every system has a boundary which can either be open, closed or semi-permeable, outlining the system from the environment, as well as every sub-system from the system itself (Chen & Stroup, 1993).

4.2.1.2 Open and Closed System Boundaries

Open systems theory refers to the concept that an organisation or system is strongly influenced by its environment. The environment consists of other organisations which impacts a system in an economic-, political- or social manner (Bastedo, 2004). Closed systems refer to the concept of a system, wherein the components only interact with one another, with no environmental interaction (Walonick, 1993).

4.2.1.3 System Components

The following table presents key concepts in systems theory.

Table 4.1: Key Concepts in Systems Theory (Walonick, 1993)

Concept	Description
Element	An element can be defined as an identifiable entity.
Pattern	A pattern refers to the relationship between two or more elements
Object	An object is defined as the existence of a pattern for any given moment in time.
Event	The change that a pattern undergoes over a period of time.
Acting System	An acting system can be defined as a system where two or more elements within the system interacts.
Component	A component refers to interacting elements in an interacting system.
Interaction	Interaction is defined as the change exerted on a component as a result of another component.
Mutual Interaction	When change is exerted in one component as a result of another component, with the result of change being exerted back onto the original component.
Interdependent	This is defined as the change in an element, as a result of another element.
System Input	System input is defined as the flow of information or matter-energy from the environment into the system.
System Output	System output is defined as the flow of information or matter-energy from the system to the environment.
System Parameter	A system parameter is any attribute of a system that can be investigated, which does not change over a period of time.

4.2.1.4 System Hierarchies

A system hierarchy can be defined as the decomposition of a system in to various sub-systems. This is done in order to study the sub-systems, which in return is a way to deal with complexity (Smith & Sage, 1973).

4.2.1.5 The Study of Systems

The study of systems can generally follow one of two approaches. The first approach is called the *cross-sectional* approach. This approach deals with the interacting between two systems. The second approach is the *developmental* approach, where the main focus of the approach is on the change experienced by a system over time (Walonick, 1993).

4.2.1.6 The Study of Sub-Systems

Sub-systems can be evaluated using three approaches. The three approaches are the *holist*-, *reductionist*- and *functionalist* approach. The holist approach consists of examining the system as a complete functioning unit. The reductionist approach consists of examining the individual sub-systems within the system. The functionalist approach consists of examining a system as a part of an even larger system (Walonick, 1993).

4.2.2 The Bitumen Import System

The bitumen import system, as stated previously, comprises of various sub-systems. The system can be defined as an acting system, with an open boundary where interaction between components take place. The bitumen import system will be analysed using both previously defined approaches. The *cross-sectional* approach will be implemented for the import process, whereupon the *developmental* approach will be introduced for the risks analysis procedure. The sub-systems, within the import system, will be analysed using a combination of the *holist*- and *functionalist* approaches. The *holist* approach is mostly used as the system is analysed as a whole, without analysing the sub-systems individually. The system will be broken down into its components, being physical, organisational and managerial, with the risk element of the managerial component being analysed more in depth. The functionalist approach was implemented in the literature review when the import system was viewed in a larger context, being viewed as part of the global bitumen industry.

4.3 Bitumen Import System Scope and Structure

The complete lifecycle system of bitumen is known as a “cradle to grave” system. This type of system analysis considers the complete lifecycle of a product, or service, through all stages of its life, being from extraction to disposal. Within this large system, various sub-systems exist. The bitumen import system was classified as a “gate-to-gate” system. *Figure 4.1* gives a representation of the “cradle to grave” system, as well as the different lifecycle sub-systems. The “gate-to-gate” system only examines the production of the product, which in this case will be the import of bitumen from the point of production by foreign refineries, to the point where the bitumen is unloaded and stored on South-African soil (Life Cycle Association of New Zealand, 2015).

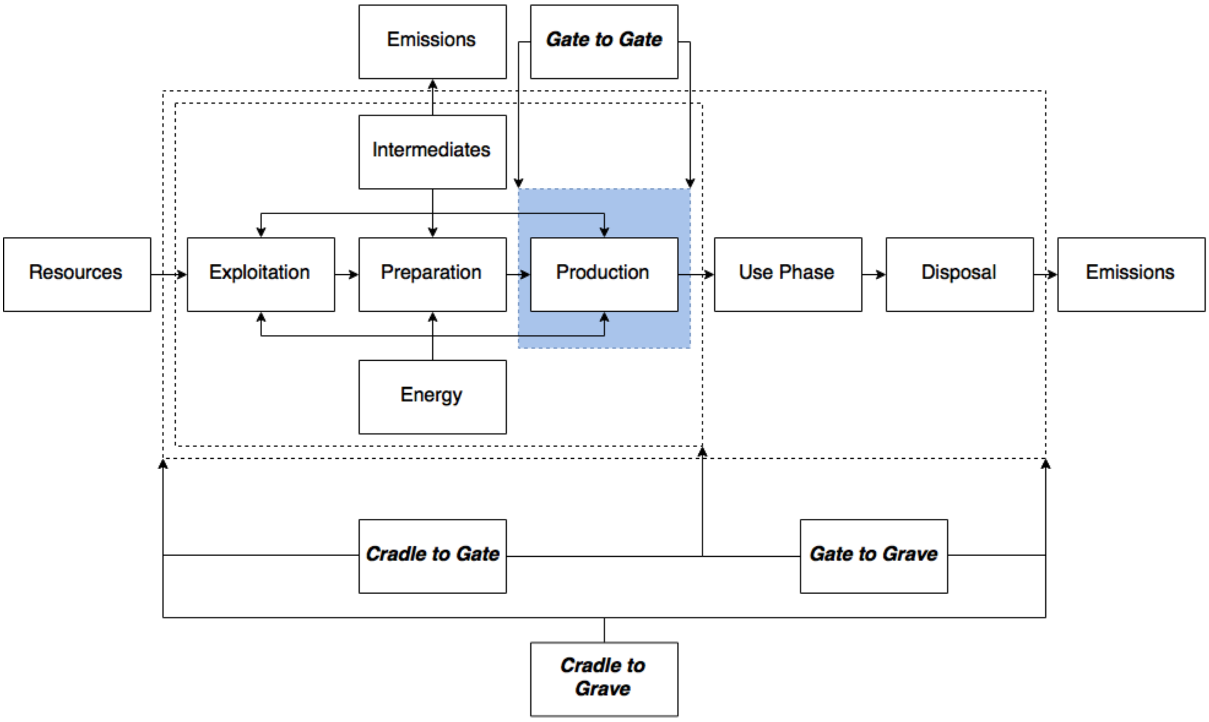

Figure 4.1: Classifications of Life Cycle Analysis (Lourens, 2012)

The production sub-system is shown in *Figure 4.2*. The figure represents the import system, from the point where the bitumen is produced by international refinery, the shipping process, unloading and storing. Transportation from the port to storage facility, if needed, is also taken into consideration. The components of this sub-system will be described further on in this chapter.

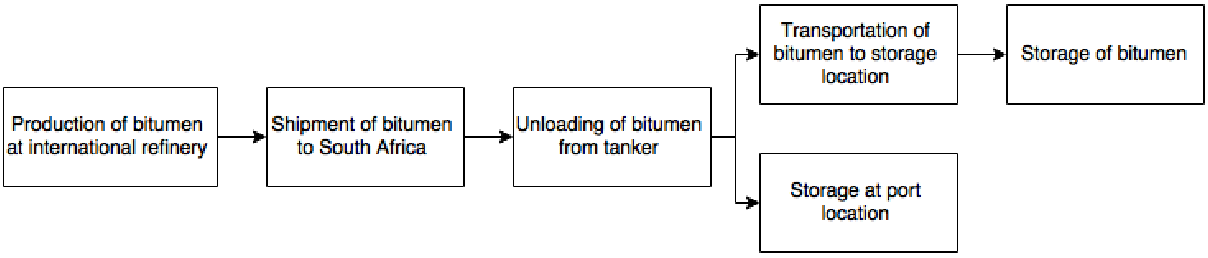

Figure 4.2: Production Sub-System of Bitumen Lifecycle System (SABITA, 2013)

4.4 Physical Components of the Bitumen Import System

The physical components of the bitumen import system refer to the manufacturing-, transport- and storage elements. The manufacturing of bitumen will be described in short. The transport- and storage elements will be fully defined.

4.4.1 Manufacturing of Bitumen

Bitumen is refined from crude oil. Crude oil originates from the remains of organic matter and marine organisms which are deposited with mud and fragments of rock on the ocean bed (Read & Whiteoak, 2003:460). Most crude oil for use in South Africa is imported, about 91% with the rest being locally sourced and refined by South African refineries. The products which are obtained from the refining process is displayed by *Figure 4.3*, along with the refineries where they are produced. Other bitumen specific companies such as Colas and Tosas are not responsible for the refinement of bitumen from crude oil. However, the organisations specialise in the modification and distribution of bitumen (Colas, 2013).

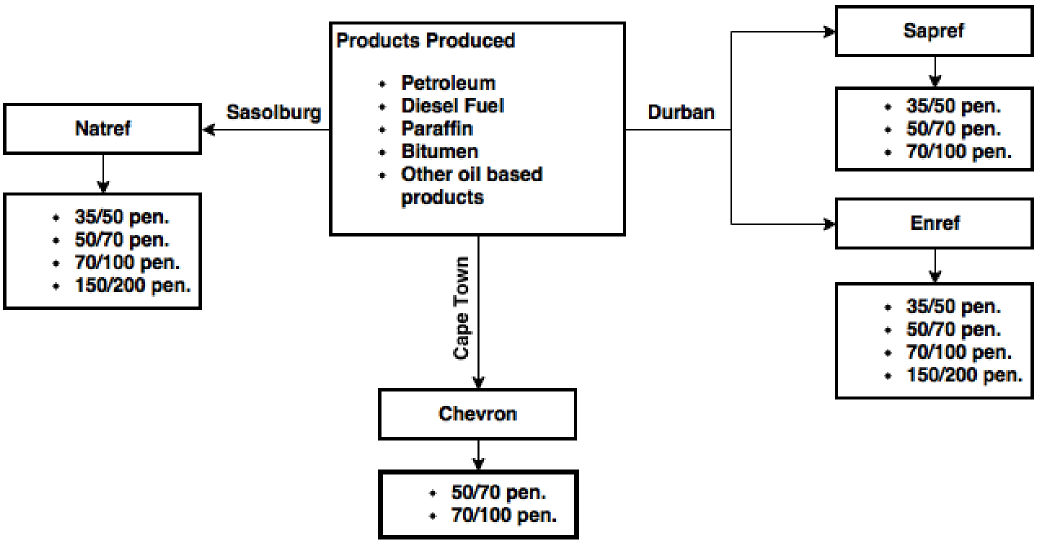

Figure 4.3: Crude oil refineries in South Africa (Department of Energy, 2012),(Van Heerden, 2009),(Mathew & Krishna Rao, 2006:23.1)

The process of refining bitumen starts with fractional distillation, which is carried out in tall steel towers, known as fractional distillation columns. Upon entering the distillation plant, the crude oil is heated to a temperature which ranges between 350°C and 380°C, at a pressure which is slightly above atmospheric pressure. The heated crude oil which enters the plant comprises of different weight fractions. The gas fractions, also known as the lighter fractions, rise up in the column and are extracted by means of horizontal steel trays, placed within the distillation column. The heavier fractions of the crude oil are extracted from the bottom of the distillation column, and are mainly comprised of liquid. The range of weight fractions, which are produced by the distillation process of crude oil, is as follows and is listed from lightest fractions to the heaviest fractions: Butane; Propane; Naphtha, Kerosene; Gas Oil, and Long Residue (Read & Whiteoak, 2003:460).

Long residue, being the heaviest fraction taken from the crude oil distillation process, comprises of a complex mixture of high molecular weight hydrocarbons. The long residue is further distilled in a vacuum distillation column at about 10 to 100 mmHg at a temperature which ranges from 350°C to 425°C. During this process the long residue is fractionated into heavy gas oil, distillates and short residue. The short residue is used to produce over 20 different penetration grades of bitumen (Read & Whiteoak, 2003:460). The penetration grade of a bitumen type is specified by means of the penetration and softening point test (ENGEN, 2009). The softening point test, also known as the Ring-and-Ball test, has established itself as a valuable and consistent test for control in refining operations of bitumen. The test is an indirect measure of viscosity, or an indirect measure of the temperature at which a certain viscosity is visible (Nanyang Technological University, 2002). The Penetration test can be defined as the distance, measured in tenths of millimetre (dmm), that a standard needle which has been pre-heated in oleic acid can penetrate a sample of bitumen under a load of a 100g which is applied for five seconds at a constant temperature of 25°C (SANRAL, 2011). The penetration test is specified in the ASTM D5 codes and in the ASTM D36 codes of practice. After the penetration of the bitumen is measured it is classified into standard penetration ranges in accordance with the SANS 307 standards (SANRAL, 2011). Furthermore, it is stated that South African refineries produce four main grades of bitumen. These penetration grades of bitumen are as follows (ENGEN, 2009): 35/50 pen.; 50/70 pen.; 70/100 pen.; 150/200 pen. When referring back to *Figure 4.3*, it shows which refinery produces which grade of bitumen.

The harder penetrations grades of bitumen, 35/50 penetration grade and 50/70 penetration grade, is used for the manufacture of hot mix asphalt for bases and wearing courses. The softer, 70/100 penetration grade and the 150/200 penetration grade, is used in spraying and chip application in road construction (ENGEN, 2009). Furthermore, these standard penetration grades of bitumen are used as the base material for modified bitumen. Modified bitumen is needed for extreme or exceptional circumstances where bitumen has to be placed on steep gradients, very high road surface temperatures, high traffic loading zones or heavily trafficked intersections. The standard penetration grade bitumen is modified using polymers, aliphatic synthetic wax, naturally occurring hydrocarbons and crumb rubber (SABITA, 2007). The way in which refinery product flows through a typical refinery can be seen in *Figure 4.4*.

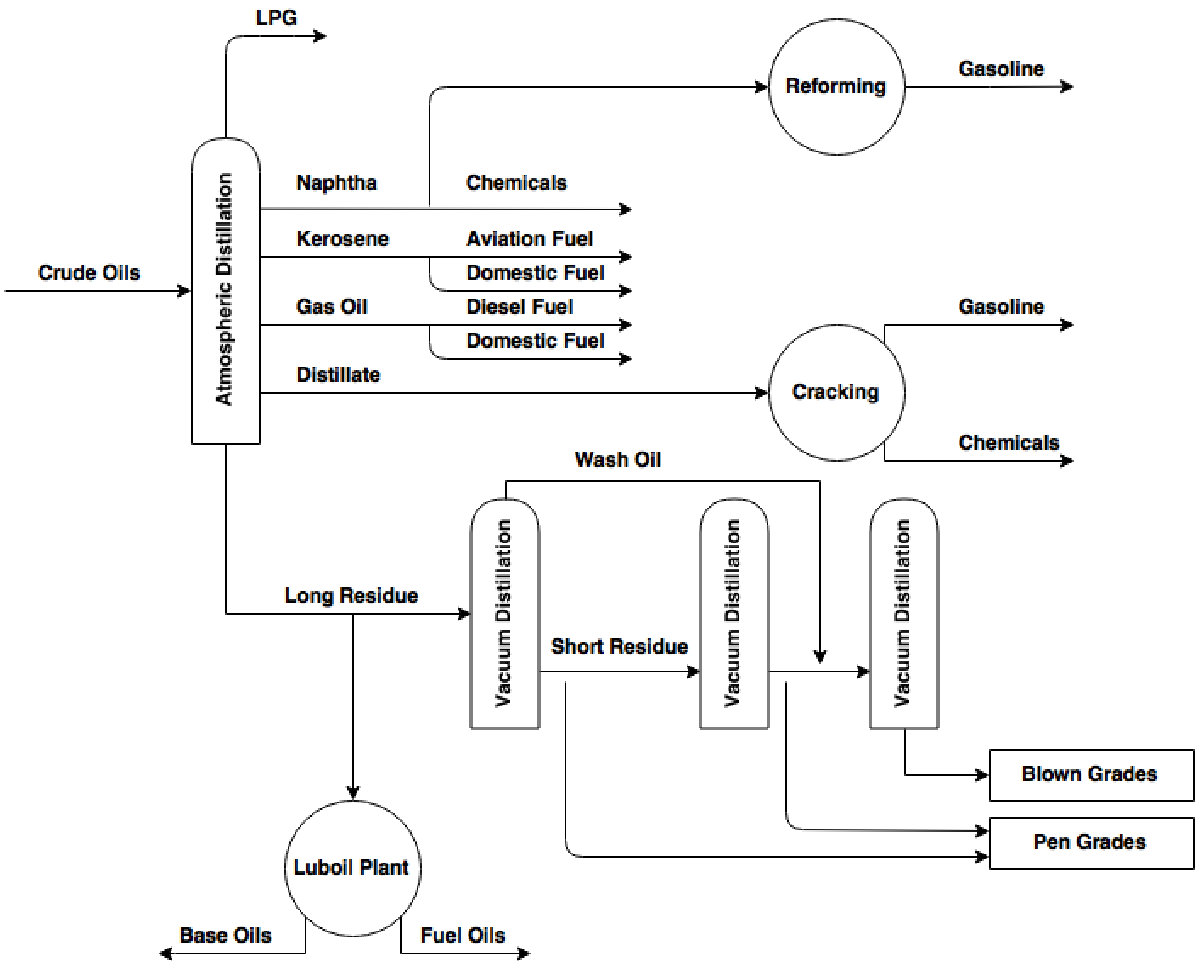

Figure 4.4: Refining of Bitumen Displayed in a Simplified Diagram (Read & Whiteoak, 2003:460)

4.4.2 Methods for Transporting Bitumen

When importing bitumen as bulk liquid cargo, the means of transport and the way in which the product is stored on the ship is essential to ensuring efficient and optimised transport of large liquid volume products (SABITA, 2013). The bitumen to be imported is penetration grade bitumen. The following section will describe import by means of bitumen tanker vessel, bitumen bags and bitutainers.

4.4.2.1 Bitumen Tanker Vessel

Due to the large volumes of bitumen imported at once, accompanied by the specialised handling requirements (cargo pumps, heating, tank and piping insolation) of the product, bitumen is usually imported using specific built bitumen tanker vessels. In terms of oil tankers, bitumen tankers are relatively small compared to other oil takers, as well as being more complicated in terms of design due to additional equipment such as complex- heating and unloading pump systems, and electronic measuring equipment. The cargo capacity of general bitumen tankers is between 3500MT and 10000MT and on average around 5000MT (SABITA, 2013). According to a document by *Iver Ships*, a bitumen tanker has four separate tanks, with three out of the four tanks having an average volume of 720 m^3 and one tank having an average volume of 470 m^3. The total volume of the bitumen tanker is 5342,176 m^3 at a capacity of 98%. The tanker's heating system can heat the bitumen to a maximum temperature of 200°C, also allowing for unloading at 200°C (Iver Ships, 2014).

The complicated design and operation of these ships results in ship-owners being reluctant to invest in these ships. This, as a result, makes for low availability of these tankers. Ensuring the availability of a bitumen tanker requires additional planning by the importer, minimising the risk of further delays (SABITA, 2013). The unloading time will also need to be taken into consideration. In 2012 Colas imported 3849 MT of bitumen, using a bitumen tanker to import the product. The unloading of the bitumen was done using bitutainers and road tankers. As an example, according to the Colas, the unloading of the ship took two days. It was stated that unloading would have been quicker if there had not been a shortage in bitutainers and road tankers (Colas, 2013).

4.4.2.2 Bitumen Bags

The bitumen packing system consists of three elements, designed to optimise the way in which bitumen is stored, transported and distributed in cold condition. The three elements of the system is the cooling and packing unit, the bitumen bag and the bitumen melter. According to the Pörner (bitumen bag developer) bitumen bag manual, the packing unit can be filled at a rate of ten tons per hour, and can be operated 24 hours a day. Each unit has a nominal packing volume of 950 kg. The bitumen is heated to a specific temperature to ensure that the bitumen can still be pumped. The packing temperature is however low enough not to damage the bags, also ensuring easier handling of the packed product. Pörner has also stated that bags will ensure that no gasses are emitted by the bitumen (Pörner Gruppe, 2012). *Figure 4.5* gives a representation of the bitumen bag filling, storage, transportation and re-heating systems.

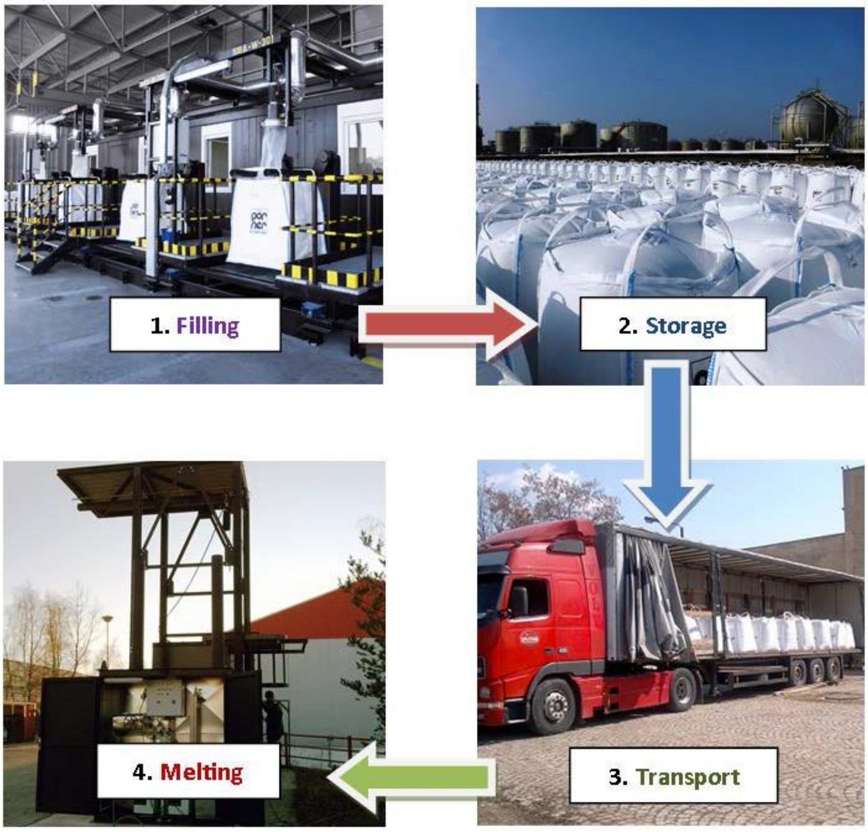

Figure 4.5: Bitumen Bag complete system (Pörner Gruppe, 2012)

The second stage of the packing system is the bitumen bag itself. The bag has a self-stabilizing design with a maximum capacity of a 1000 kg of bitumen. The bags were designed to optimise storage as well as ensuring that none of the product is wasted when retrieving the product from the bag. The way in which this is done, as stated by Pörner, is developing the bag with an inner lining that melts away with the bitumen at the target destination. The bearing outer bag can be recycled, but cannot be used more than once (Pörner Gruppe, 2012).

The final step of the bitumen packing process is the bitumen melter. The melter has a capacity of up to 4 tons per hour and makes use of a two-step process. The cold bitumen is first liquefied and then further heated inside a storage tank to a temperature of 160°C. The storage tank is a six meter tall tank with a volume of approximately 27 m^3. From the storage tank, bitumen can be pumped to any other larger storage tank. The cold storage combined with a high mobility, and easily maintained, melting equipment allows for batch plants to be moved as needed, with no quality loss at a relatively low price (Pörner Gruppe, 2012).

4.4.2.3 Bitutainer

Bitutainers can be best described as cargo containers being utilised for the transport and storing of bitumen. The container is constructed at the same size as normal cargo containers in order to simplify transportation. The container is constructed to avoid pilferages and contamination, as well as being constructed using hazard free and environmentally friendly materials. The container has a nominal capacity of 29 000 litres and is fitted with a high performance heating system. The containers can be stacked on top of one another, and transported by means of a cargo ship (Seashell Logistics, 2013)(Anderson, 2013). *Figure 4.6* gives a representation of the bitutainers.

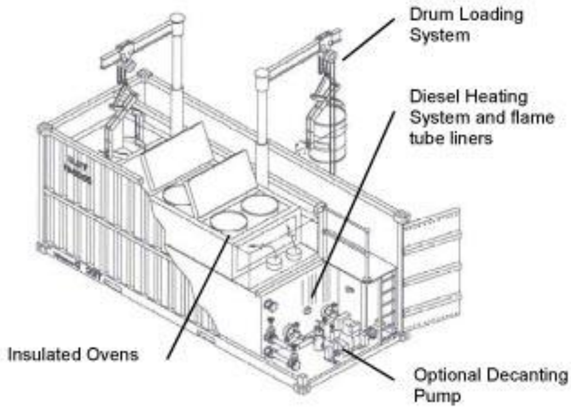

Figure 4.6: Bitutainer design as seen on (Tectainer, 2015)

4.4.2.4 Steel Drums

Cold bitumen transport using steel drums is one of the oldest methods used for bitumen storage and transportation. Over the years, the steel drums have undergone optimising, in terms of material treatment, type and thickness, in order to decrease product loss. The optimisation of the steel drums also allows for efficient use of steel per volume of bitumen. The largest of the steel drums are designed to be 1m high with a steel thickness of 0.8 mm and is able to store 200 kg of bitumen (Orinoco Oil, 2014). In order to use steel drums for cold storage, and for transportation purposes, it is required that the steel drum producer is located near the bitumen refinery. The steel drums transport method has also been criticized due to a 3% to 8% product loss as well as the high cost of treated steel for the production of these containers (Pörner Gruppe, 2012). *Figure 4.7* gives a representation of a steel drums used for bitumen importation.

Figure 4.7: Bitumen import using steel drums (Isfahan Bitumen, 2015)

4.4.3 Methods for Storing Bitumen

When importing bitumen, importers have to decide on an effective way of storing bitumen. The storing method must ensure easy accessibility when needed, and allow for efficient extraction of the bituminous product. During the interviews, the importance of adequate storage was stressed by various parties. For a potential importing company, storage played a significant role in the decision making process (A. Robinson, 2015). Different methods exist for the storing of bitumen, whether on site near the batch plant or near the harbour. The following section will describe the storage techniques used with the different importing methods as previously described.

4.4.3.1 Bitumen Transport Tankers

When using bitumen tanker vessels as transport method, the unloading of the product has to be planned beforehand due to large cargo dues if the vessel is docked for a long period of time (SABITA, 2013). The bitumen must be unloaded using bitutainers and bitumen road tankers (Colas, 2013). The bitumen can also be stored in a tank farm near the port, but requires the port to facilitate bitumen unloading by means of a fixed pipeline to the tank farm (SABITA, 2013). Unloading of the bitumen tanker vessel using the bitumen bag system will increase the unloading time, as the bitumen bags have a smaller volume, as well as the packing system requiring a bit of time. The vessel can also be unloaded using bitutainers.

4.4.3.2 Bitumen Bags

The bitumen bags were designed to use for transportation as well as storage. The bags can be stored in warehouse or outside, and can be stored for long periods of time without product loss. The square shape of the bitumen bag enables efficient packing when stored. However, it is not recommended that bags be stored on top of another due to the large weight of the bitumen bags, resulting in large storage space needed (Pörner Gruppe, 2012).

4.4.3.3 Bitutainer

Bitutainers are designed for transportation and storage of bitumen. As previously mentioned, each container contains a heating system, thus the bitumen can be kept in the container and transported to the designated area. Upon arrival on site, the bitutainers can be stacked up as done for general container yards and used as needed (Seashell Logistics, 2013).

4.4.3.4 Steel Drums

Steel drums can be stored outside or within a warehouse (Orinoco Oil, 2014). If the product is delivered to the site it can be stored near the batch plant where the bitumen will be retrieved. Packing large quantities of steel drums, however, will need a large storage area as the cylindrical shape of the drum does not allow for the most optimised packing structure. Furthermore, for a large road construction project, large quantities of steel drum packed bitumen will be needed, due to the low volume of bitumen stored within a single drum (Pörner Gruppe, 2012).

4.5 Organisational Components of the Bitumen Import System

The organisational component refers to the parties involved in the import process. The different parties, or elements of the component, are the exporting party, importing party, shipping company, shipping agent and sub-contractor. Each of the elements will be described in the following section.

4.5.1 The Exporting Party

The exporting party refers to an international supplier or international distributor. In the case of bitumen, the international supplier will most likely be an international refinery, which produces bitumen. In order to decrease risk, business should be conducted directly with the supplier or bitumen producer, avoiding business with trading companies or third party suppliers (J. Fourie, 2015).

4.5.2 The Importing Party

The importing party refers to the South African based organisation, being a privateer, client, contractor or bitumen distributor. As stated previously, the only bitumen to be imported into South Africa, was done by a bitumen distributor (Colas, 2013).

4.5.3 Shipping Company

When importing bitumen, the mode of transport will be by shipping vessel. The shipping company plays an important role in the bitumen import system. When selecting a shipping company, the method of transporting bitumen, being either by specialised tanker, bitutainers, bitumen bags or barrels, should be taken into consideration. The shipping company should also have a respected reputation in the industry, in order to avoid disputes and delays.

4.5.4 Representative Party on behalf of the Importer (Shipping Agent)

In the interview with Mr.Fourie (2015), the appointment of a shipping agent was mentioned. The shipping agent reduces risk for the importer, acting on behalf of the importer to ensure product quality. According to Mr. Fourie, one of the most respected organisation, specialising in Shipping Agents, is SGS S.A. (formerly Société Générale de Surveillance). The company is headquartered in Geneva, Switzerland, and specialises in the verification of the quantity, weight and quality of traded goods, as well as testing the product quality and performance against various health, safety and regulatory standards.

4.5.5 Sub-Contractor

Sub-contracting companies, if needed, are used for the unloading of bitumen. For the unloading process additional transport vehicles, pumping systems for unloading and import management specialists will be most likely needed.

4.6 Managerial Components of the Bitumen Import System

The managerial component of the bitumen import system refers to any element which requires managerial actions. This section will describe the financial-, logistic-, quality-, health-, safety-, environmental- and contractual management elements.

4.6.1 Financial Management

The section reports on the financial aspects of the importation of bitumen. The section will describe and define the costs involved, the obtainment of a Letter of Credit (LC), and the different payment options to be used.

4.6.1.1 Costing Options

For the international trade of commodities, the export pricing is governed by different costs besides the cost of the exported goods. These additional costs refer to customs clearance-, freight-insurance-, loading- and unloading finances. The contract document should clearly state which party is responsible for the additional costs. Furthermore, it is important that both the exporting and importing party are informed when dealing with the trading terms. In order to standardise this procedure, as well as ensuring fair risk distribution between parties, the International Chamber of Commerce (ICC) developed the *Incoterms*. According to the Foreign Exchange Dealers'

Association of India (FEDAI) guideline, the incoterms have four main categories. The four categories are shown in *Table 4.2*. A description of the categories will be stated thereafter.

Table 4.2: Incoterms - Four Main Categories (Rajib, 2015)

Group	**Term**
Group E (Departure)	EXW (Named Place)
Group F (Main Carriage Unpaid)	FCA (Named Carier) FAS (Named Place) Free on Board (Named port of Shipment)
Group C (Main Carriage Paid)	CFR (Named port of Destination) CIF (Named port of Destination) CPT (Named port of Destination) CIP (Carriage Insurance Paid to)
Group D (Arrival)	DAF (Named Frontier) DES (Named port of Destination) DEQ (Named port of Destination)

Table 4.3 are the description of the groups, as seen in *Table 4.2*.

Table 4.3: Incoterms Group Descriptions (Rajib, 2015)

Group	**Description**
Group E	Seller makes goods available for collection at the seller's premises.
Group F	The seller is responsible for the transportation of the goods to a carrier appointed by the buyer. The seller does not bear the expenses of the carrier.
Group C	The seller is responsible for contracting a carrier company. The seller bears the cost of transportation, but does not take risk, or any event after shipment, in to consideration. The seller bears only a portion of the total cost.
Group D	The seller bears all the costs, being transportation and additional risk contingency measures.

The terms used for the description of the groups as seen in *Table 4.2*, will be defined in the following section.

EXW (name of place)

This term indicates that the seller is responsible for making the goods available at the factory or refinery for collection. The term EXW is used to describe ex warehouse. Once the buyer collects the goods, all risks associated with transportation as well as any additional costs, are borne by the buyer (Rajib, 2015).

Free on Rail (FOR)/Free on Truck (FOT)

The term is used when the seller is responsible for the transportation of goods to the carrier location, as nominated by the buyer. Once the seller fulfilled the obligation of getting the goods to the carrier, all further costs are borne by the buyer (Rajib, 2015).

Free alongside Ship (FAS) (name of the loading port)

The seller is only responsible for costs to get the goods alongside the ship. The buyer is then responsible for loading, shipment and unloading. The buyer bears all the risk product loss, and all additional risks associated with shipment, from the point when the seller fulfilled the terms of contract (Rajib, 2015).

Free on Board (FOB) (name of port of shipment)

The seller has the responsibility of transporting the goods to the nominated port of shipment, as well as loading the goods on board. Once the seller has fulfilled his obligations, all further risks are borne by the buyer. Upon completion of loading the goods, the "*Receive for Shipment Bill of Lading*" should be converted to "*Shipped on Board Bill of Lading*". The bill of lading will be explained for the logistics management component. In addition, costs associated with export customs clearing and documentation charges are borne by the seller (Rajib, 2015).

Cost and Freight (C&F) (named port of destination)

The seller bears the costs of transportation, loading and shipment. Once the goods reach the port nominated by the buyer, the point of deliver is fixed to the ships rail. The expenses from arrival of ship at destination port are borne by the seller (Rajib, 2015).

Cost Insurance Freight (CIF) (named port of destination)

For CIF the seller has the responsibility to ship the product to the nominated destination port, as well as insuring the product for damage or loss until the product reaches the destination port (Rajib, 2015).

Freight or Carriage Paid (DCP) (named destination)

DCP is a term used for any international transportation of products by road, rail and inland waterways. The seller is responsible for the cost of the goods to the nominated destination point. Should the buyer request insurance on the product, the contract will be amended, stating "*including insurance*" before the term DCP (Rajib, 2015).

EXS/Ex-Ship (named port destination)

The term is used for contractual agreements where the seller is responsible for the transportation of the product to the nominated port. The seller is also responsible for the loading- and insurance costs until the product is loaded. From this point foreword the buyer bears the costs associated with freight, insurance, customs clearing, documentary requirements and unloading (Rajib, 2015).

EXQ/Ex-Quay (named port of destination)

The seller is responsible for making the product available in the quay. All additional costs associated with the unloading of product from the ship to designated quay area is borne by the buyer (Rajib, 2015).

Deliver at Frontier (DAF) (named place)

The frontier refers to the border between countries. The seller is obligated to transfer the goods to the border. Once the goods arrive at the border, costs associated with risk and insurance, shifts from the seller to the buyer (Rajib, 2015).

Deliver Ex Ship (named port of destination)

The seller is responsible for all costs associated with transferring the product from the refinery to the nominated port of destination (Rajib, 2015).

Delivered Ex Quay (Duty Unpaid) (named port of destination)

The seller is responsible for all costs associated with transferring the product from the refinery to the nominated quay of destination. Import clearance costs, as well as import duty, are borne by the buyer (Rajib, 2015).

4.6.1.2 Obtaining a Letter of Credit

A Letter of Credit (LC) is provided by the buyer's financial institution, and acts as a secure and flexible payment method. The LC, being a combination of a guarantee and a payment order, is an irrevocable assurance that the buyer can pay. The LC can also function as a seller's credit. Furthermore, LC's are recommended for transactions where new business partners are involved, business markets with uncertain social and political conditions, import of specialised products and where large amount of product is imported at once. The advantages of an LC are as follows (Handelsbanken, 2014):

- Delivery time can be controlled;
- Advance payments can be avoided;
- Business in uncertain markets are facilitated;
- The seller has to fulfil conditions of LC for payments to be made;
- The seller can start manufacturing at an earlier time;
- The option of extended payment is possible, and
- LC's are subject to internationally recognised regulations.

The way in which an LC works is displayed by *Figure 4.8*, whereupon descriptions are given in *Table 4.4*.

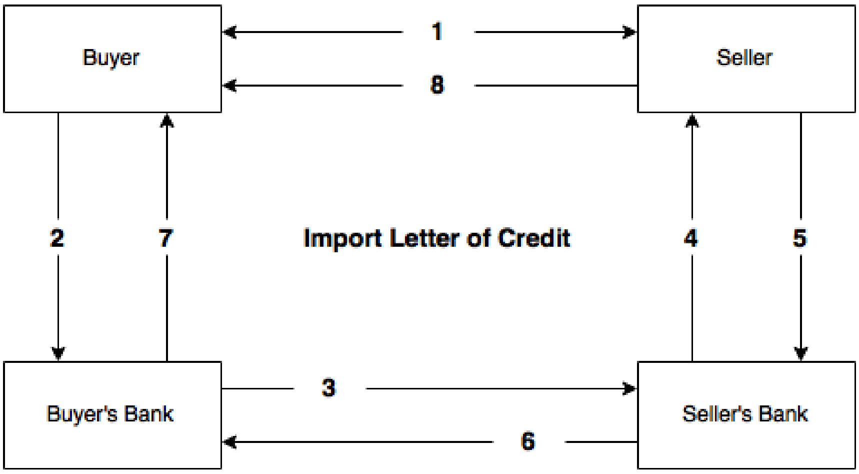

Figure 4.8: How Import Letter of Credit Works (Handelsbanken, 2014)

The following are the descriptions of the steps, as numbered in *Figure 4.8*.

Table 4.4: Letter of Credit Cycle Description (Handelsbanken, 2014)

Number	Description
1	Buyer and Seller has to agree on the terms of the contract.
2	The buyer's bank will then be asked to open a LC.
3	The buyer's bank sends the LC to the seller's bank.
4	The seller's bank has to inform the seller that an LC has been opened.
8 (Delivery)	The goods can then be delivered to the buyer, whereupon documentation is sent to the seller's bank.
5	The required documentation is submitted to the seller's bank.
6	The seller's bank examines the documentation against what is required by the LC, and sends all necessary documentation to the buyer's bank.
7	The buyer's bank examines the documentation, and upon approval transfers the money to the seller's bank. The goods can thus be accessed.

4.6.2 Logistics Management

Logistics management can be defined as an integrating function which aims to coordinate and to optimise all logistical activities (USAID, 2011:162). The logistics management section aims to report on the procedural- and documentation requirements associated with bitumen importation. The section will describe the import control regulations, sourcing of bitumen, shipping limitations, documentation needed for customs clearing, shipping documentation needed, import procedure and the ports cargo handling and storage.

4.6.2.1 Import Control Regulations

Bitumen is subject to import/export control and requires that any organisation or individual attempting bitumen import into South Africa to have an import permit. The bitumen import permit is administered by the International Trade Administrations Commission of South Africa (ITAC). For authorisation of an import permit, the Economic Development Department should be contacted for necessary procedure guideline (SABITA, 2013). According to ITAC, applicants for a bitumen import permit must first register with the South African Revenue Service (SARS) as a user of rebate item 460.05/2713.20/01.06. The import permit for bitumen is valid for a calendar year. Also, bitumen imported into South Africa is subject to import duty. The ITAC conditions for bitumen permits can be found online (ITAC, 2015).

4.6.2.2 Selecting a Suitable International Supplier

Various international bitumen suppliers exist. It is however preferable to use an international bitumen supplier which has access to comprehensive procurement and supply chain management services. Potential buyers have the responsibility of investigating any bitumen supplier from which they wish to import, making sure the supplier is trustworthy. The supplier should also have experience the field of bitumen exportation. According to the SABITA import manual, the following criteria have to be taken into consideration when selecting a supplier (SABITA, 2013):

- Is there sanctions or trade embargos which could hinder, or prevent, exportation from that specific country?
- The bitumen supplier should also be the manufacturer thereof. This statement is supported by information gained from Mr. Fourie in *Section 4.5.1*.
- The crude oil source, from which the bitumen is produced, should be stated. Not all crude oils are suitable for production of appropriate quality bitumen.
- The supply capacity of the supplier must be known.
- The supplier should state how bitumen quality is guaranteed and verified.
- Is the supplier capable of managing supply chain processes, or should a third party be contracted?
- The supplier should be compliant with internationally accepted standards in connection with health, safety and environmental management.

4.6.2.3 Import Duty

Import duty can be defined as the tax collected by customs authorities on imports, as well as tax collected on certain exports. The tax is used to increase state revenue. The tax is calculated based on the value, weight, dimension or other criteria associated with the product. Import duty can also be referred to as customs duty, import tax and import tariff. The rates for imports are listed by SARS. Different rates are applied depending on the exporting countries' trade relationship with South Africa (Investopedia, 2015). The rates published by SARS can be seen in the S*chedule to the Customs and Excise Act, 1964 (Tariff Book).* In 2013 an article was published stating that a new duty-rebate provision was adopted in order to mitigate South Africa's bitumen shortages. The duty-rebate was confirmed by the International Trade Administration Commission of South Africa (ITAC). The rebate provision was implemented to cater for duty-free importation of petroleum bitumen during the time of shortages (Esterhuizen, 2013).

4.6.2.4 Documentation Needed for Customs Clearing

The following documentation is needed for customs clearing. The documentation which will be described in this section is the commercial invoice, customs invoice, consular invoice and the certificate of origin.

Commercial Invoice

The commercial invoice is an accounting document that is presented to the buyer from the seller. The commercial invoice is a description of the product, associated costs, transaction terms, transaction currency, addresses of both buyer and seller, and the tariff classification used by the buyer's country. The commercial invoice is not just needed for customs clearing, but is also needed for the Letter of Credit (LC). The commercial invoice defines the transaction throughout the import system. The commercial invoice is needed by both the seller and buyer. The seller requires the commercial invoice for authorisation of payment, being that the contractual obligations, payment terms and product description confirm to that outlined by the LC. The buyer requires the commercial invoice for customs clearance purposes (SGS S.A., 1998:129).

Customs Invoice

A customs invoice can be defined as an extended form of the commercial invoice. The customs invoice states all the data associated with the imported product.

Consular Invoice

A consular invoice can be defined as a sighted, signed and stamped commercial invoice. This has to be done by the consul of the importing country which resides in the exporting country.

Certificate of Origin

The certificate of origin is defined as a signed statement, which proves the origin of the product being exported. The certificate of origin is completed by the exporter and is usually obtained from a semi-official organisation, such as the local chamber of commerce (SGS S.A., 1998:129).

4.6.2.5 Shipping Documentation Needed

The shipping documentation which will be described in this section includes the original bill of lading, certificate of origin, commercial invoice, third party inspection report certificate, packing list and insurance certificate.

Original Bill of Lading

The bill of lading is regarded as one of the most important pieces of documentation required for international trade. The bill of lading has three functions. The first is, the bill of lading acts as evidence of the contract of carriage. The contract of carriage is the contract between the carrier and the shipper. The second function of the bill of lading is that it acts as a receipt. This receipt is proof that the product is loaded on board of the shipping vessel. The third function of the bill of lading is that it acts as evidence of the title of shipped goods. Evidence of the title of goods refer to the ownership of the goods whilst in transit (SGS S.A., 1998:129).

Certificate of Origin

The certificate of origin is defined in the previous section.

Commercial Invoice

The commercial invoice is defined in the previous section.

Third Party Inspection Report Certificate

When importing bitumen, buyers should request a third party inspection of the product. This is done to ensure that the quality of the product is according to the specification standards of the destination country. The specification standards will be defined in a later section. The inspection certificate provides the following (SGS S.A., 1998:129):

- The product is physically inspected in the country of origin, ensuring that it matches description of exporter.
- The contract price is verified. This is done to ensure that the price paid by the importer is relative to the market.
- Provides accurate data for customs documentation.
- The product is inspected against any list of items subject to specific import regulations.

Packing List

The packing list acts as a complimentary document to the commercial invoice, providing relevant information to the buyer, shipping company, financial institutions and customs authorities. The packing list is also a required piece of documentation needed for LC authorisation. The packing list notes the physical qualities of the product on board, being type, gross weight and amount of product (SGS S.A., 1998:129).

Insurance Certificate

The insurance certificate is a piece of documentation needed for shipping purposes. The documentation states that the product is insured against loss or damages whilst in transit (SGS S.A., 1998:129).

4.6.2.6 Import Procedure

The import procedure as identified by Mr. Fourie consists of the following steps (J. Fourie, 2015):

- Buyer requests Full Corporate Offer (FCO) from seller, which will stipulate most of the trading terms and specifications.
- The FCO is signed and in return the buyer is subject to an inspection of the refinery, loading port and table top meeting with the seller to finalise the terms and conditions of the contract.
- Payment terms are negotiated, with emphasis being placed on the shipping documentation.
- The buyer is responsible for Free on Board (FOB) costs, which includes insurance to discharge port, whereupon the buyer is responsible for cost of clearance.
- A shipping agent is appointed.

- One of the best organisations to use as shipping agents is SGS S.A. They specialise in verification of the quantity, weight and quality of traded goods, as well as testing the product quality and performance against various health, safety and regulatory standards. They make sure that the product, systems or services meet the requirements of standards set by governments.
- An unconditional, irrevocable letter of credit (LC) is requested, as to protect both buyer and seller.
- Payments are normally made by the bank which authorised the LC.
- Payments are made using Telegraphic Transfer (TT) from the buyer's bank to the seller's bank, with the payment normally taking up to three weeks.

4.6.2.7 Ports Cargo Handling and Storage

When importing bitumen, the buyer has to consider the logistics management surrounding the unloading of the bitumen. This is required as South Africa has no bitumen specific ports, thus external pumping systems should be designed (SABITA, 2013). In 2012 when COLAS imported bitumen, a specialised gantry was constructed, which included a pumping system, in order to unload the bitumen into road tankers. The gantry which was constructed could pump bitumen from the shipping vessel into three trucks simultaneously (K. Louw, 2015). Upon unloading of the bitumen, bitumen storage tanks, or facilities, should be in place. The storage facility should be able to handle between 5000 MT and 10000 MT of the product. The port itself, which will be used for unloading purposes, should have sufficient water depth alongside to accommodate for the anticipated draught requirements of bitumen tankers (SABITA, 2013).

4.6.2.8 Reference Guides and Legislation

According to the bitumen import guide published by SABITA, the following guides and regulations should be considered before importing bitumen (SABITA, 2013).

4.6.2.8.1 Standards and Specifications

- SANS 4001-BT1:2012, Edition 1.1 - Penetration grade bitumen. Covers product specifications of four penetration grades of bitumen suitable for road construction and similar purposes;
- SANS 10089-1:2008 Edition 4.3 - Storage and distribution of petroleum products in aboveground bulk installations;

4.6.2.8.2 Legislation

- Occupational Health and Safety Act (Act 85 of 1993 as amended) and applicable Regulations;
- International Trade Administration Act, (Act 71 of 2002): Import control regulations, Government Gazette No. 35007, 10 February 2012;
- National Ports Act (Act 12 of 2005);
- PORTS RULES, National Ports Act (Act 12 of 2005), 6 March 2009, Department of Transport;

- Guidelines for Agreements, Licences and Permits in terms of the National Ports Act (Act 12 of 2005), Transnet National Ports Authority 25 April 2008;
- Liquid Bulk Terminal Operator Licence, Transnet National Ports Authority, 1 December 2011;
- Harbour Master's Written Instructions, 2007 issued in terms of the National Ports Act (Act 12 of 2005)

4.6.2.8.3 Industry Publications

- SABITA Manual 2: Bituminous products for road construction and maintenance, Fifth edition, September 2012;
- Industry Protocol for Responding to Bitumen Spills on Land and/or Adjacent Water Environments, SABITA, December 2012;
- SABITA Manual 8: Guidelines for the safe and responsible handling of bituminous products, Third edition, May 2011;
- International Safety Guide for Oil Tankers and Terminals, International Maritime Organization, Fifth edition, 2006;
- Marine Terminal Management and Self-Assessment, OCIMF, September 2012;
- Guidelines for the Handling, Storage, Inspection and Testing of Hoses in the Field, 2nd Edition, OCIMF, January 1995;

4.6.3 Quality Management and Assurance of Bituminous Product

The quality of bitumen must conform to certain standards in order to insure high volume users of bitumen, such as SANRAL, municipalities and asphalt producer, a high quality product. Different countries, however, do not make use of a universal standard, but rather follows standards and grading systems most applicable to their contracting strategies and construction techniques. The most recognised standards used around the world are the following (SABITA, 2013):

- European Committee for Standardization (CEN)
  - Deutsche Industrie Norm (DIN EN)
  - Association Française de Normalisation (AFNOR – NF EN)
  - BSI Standards – the UK's National Standards Body (NSB – BS EN)
- American Society for testing and Materials (ASTM)
- American Association of State Highway and Transportation Officials (AASHTO)
- South African Standard Organization (SABS/SANS)
- Standards Australia (AS)

In South Africa, the SANS 4001 – BT1: 2012, Edition 1.1 – Penetration Grade Bitumen, is used for the quality assurance of locally refined bitumen. The standards provide the product specifications of the four most commonly used and produced bitumen in South Africa (SABITA, 2013). The four penetration grade bitumen's are, as previously mentioned, the 35/50 pen.; 50/70 pen.; 70/100 pen.; 150/200 pen (ENGEN, 2009). When importing bitumen, importers should insure that the quality of bitumen imported conforms to the same standards. In 2013 the South African Bitumen Association (SABITA) released an import guide for companies planning on using this method of product procurement. When analysing and comparing the SABITA import guide with similar documents produced by the New Zealand Roads Authority (New Zealand Roads Authority, 2013) and CSIR (Asphalt Academy, 2007), with emphasis being placed on the quality assurance of bituminous binders, similarities arose. *Table 4.5* shows the quality assurance procedures which need to be followed, and in which manual it can be located.

Table 4.5: Quality Assurance procedures as stated by various manuals

Quality Assurance Procedure	SABITA Import Guide	New Zealand Roads Authority	CSIR – Asphalt Academy
The manufacturer should have a fixed quality control system in place with a certification equivalent to the ISO 9000 family of quality management standards (SABITA, 2013).	√	√	√
Client should confirm and accept the quality assurance process (SABITA, 2013).	√	√	χ
Use an institution which is reputable and trustworthy when doing inspection, verification, testing and certification in order to provide evidence to client that the bituminous products conform with SANS 4001-BT1: 2012 (SABITA, 2013).	√	√	χ
If the contractor does not use an external institution for testing and verification of bitumen, the contractor's Quality Assurance system should ensure that all handling procedures, storage, blending, heating and testing of bitumen are detailed beforehand and documented, to minimise and monitor changes (New Zealand Roads Authority, 2013).	χ	√	χ
The contractor should do an inspection of supplying factory and record test results from factory. The contractor must also insure that supplier keeps samples of each shipment batch of bitumen (Asphalt Academy, 2007).	χ	χ	√
In order to limit disputes, correlation testing should be performed between refinery and on-site testing institution in order to confirm similar results (Asphalt Academy, 2007).	χ	χ	√
The contractor must ensure that samples are taken from batch plant when bituminous products arrive at batch plant as well as when bitumen is used on site (Asphalt Academy, 2007).	χ	χ	√

4.6.3.1 Development of a Universal Bitumen Performance Grading System

The last 15 years has seen dramatic changes to bitumen specifications. The changes ranged from simplistic empirical tests to fundamental visco-elastic and damage characterisation methods. Various factors, such a traffic volumes and climactic differences, impose changes in specifications.

The South African bitumen standards, and others worldwide until 1990, were based on the concepts of hardness and viscosity. The specifications relied on two tests namely the Penetration and Softening Point tests, related to in-service temperatures and the viscosity related to mixing and compaction temperatures. The tests however are not directly related to performance, but are rather based on experience, as well as only being valid for penetration grade bitumen (Jenkins, Van den Ven & Bahai, 2015).

Recent studies, performed by Jenkins, van de Ven and Bahia (2015), are aimed at developing a universal performance grade specification document. The study is based on the Superpave binder specifications as implemented in the United States of America, and other parts of the world. The Superpave specifications is based on relatively new rheological testing methods, and the concept of performance grading. The specifications as implemented takes climactic conditions and traffic volumes into consideration, and can be used for penetration grade and modified bitumen. The problem however arises in the implementation of such standards. The reluctance for implementation is driven by high costs and complexity, associated with testing equipment and procedures. This being said, the development of new performance grading bitumen specifications, at an international scale, could see simplified quality management when importing bitumen. The development of such standards could ensure importers that bitumen would be tested according to the right specifications when imported. It will also allow for importers to import modified bitumen directly, decreasing costs associated with additional bitumen plant and equipment (Jenkins, Van den Ven & Bahai, 2015).

4.6.4 Health, Safety and Environmental Management

Health, safety and environmental management plays an important role in the shipping industry. It is regarded as of great importance, and managed within a strict control framework. The framework is structured with a number of regulatory requirements aimed at enhancing health, safety and environmental management awareness. The *International Safety Guide for Oil Tankers and Terminals* (ISGOTT) is the standard reference work on the safe operation of oil tankers and the terminals they serve. The ISGOTT is incorporated as a standard in the Port Rules in terms of the National Ports Act No. 12 of 2005. The guide is made up of four sections, and are describe as the following (SABITA, 2013):

- Part 1: General Information;
- Part 2: Tanker Information;
- Part 3: Terminal Information; and
- Part 4: Management of the Tanker and Terminal Interface

Part 1 and 2 of the guide is mainly focused on petroleum properties and hazards, and the handling of these products. Part 3 of the guide focuses on the compliance of shipping vessels in terms of international, national and local marine regulations. It is stated that importers should request certificates of compliance in terms of *International Convention for the Prevention of Pollution from Ships* (MARPOL) and *International Convention for the Safety of Life at Sea* (SOLAS), from their shipping agents or supplier representatives, stating that the shipping vessel complies with all standards. Furthermore, Part 4 of the guide focuses on the in-port cargo handling. The guide states that unloading operations, in terms of health, safety and environmental management, be authorised by the *Transnet Ports Authority* (TNPA). Strong emphasis is placed on the prevention of spilling of product into the harbour area. The most import chapters of Part 3 and 4, of the ISGOTT document, as stated in the SABITA import guide, are the following (SABITA, 2013):

Part 3: Terminal Information

- Chapter 15: Terminal Management and Organisation
- Chapter 16: Terminal Operations
- Chapter 17: Terminal Systems and Equipment
- Chapter 18: Cargo Transfer Equipment
- Chapter 19: Safety and Fire Protection
- Chapter 20: Emergency Preparedness
- Chapter 21: Emergency Evacuation

Part 4: Management of the Tanker and Terminal Interface

- Chapter 22: Communications
- Chapter 26: Safety Management

4.6.5 South African Construction Contracts and Importing Bitumen

South African construction contracts do not contain set clauses for cases where products are imported. In the case of importing goods, clients can insert clauses into construction contracts to cater for imported goods. The inserted clauses are agreed upon between client and contractor. The South African National Roads Agency (SANRAL) currently use the FIDIC set of documents for road construction. It was stated by the client party that the risk of sourcing bitumen is deemed to be the contractors. From the client's perspective, the only concern with the bitumen being used, whether imported or locally sourced, is that it has to comply with the South African bitumen specifications (G. Fourie, 2015). This information is supported by interviews conducted as seen in *Appendix A*.

4.7 Conclusion

The chapter aimed at producing a document which sees the import procedure as a system, analysing the various components and elements associated with the system. The system itself was seen as a gate-to-gate system, only looking at the production phase of the bitumen, which in this case is the importation thereof. The system was divided into its various components, being physical, organisational and managerial. The physical components related to the import method as well as the storage method. It was seen that importation via shipping vessel is the most cost effective method when importing large quantities of bitumen. For smaller amounts, bitutainers or bitumen bags can be used, with steel drums not being recommended as losses are experienced during extraction of the product.

The organisation components discussed the various parties involved, being the client, contractor, sub-contractor, shipping company and 3de party representatives (shipping agents). From the interviews, it was stated that one of the largest shipping agent companies is SGS S.A. The shipping agent organisation is responsible for product testing at the refinery location, before the product is shipped. Furthermore, the managerial component of the bitumen import system was divided into various elements namely financial-, logistical-, quality-, health-, safety- and environmental management. For the financial management element, the importance of a LC was stressed, and deemed to be essential to the operation. The logistical element was defined in terms of the different documentary requirements associated with the bitumen import system, as well as stating the import procedure to be followed. Should an organisation consider such an operation, the United Nations and SGS have developed a document specifically defining the documentary risk in commodity trade. A document checklist can be found at the end of this guideline document (SGS S.A., 1998:129).

The SABITA import guide was referenced for the quality assurance of the bitumen, in which the different standards were stated. The SABITA import guide was also referenced for the ports cargo handling and port safety operations. This procedure defined as health, safety and environmental management is deemed to be of utmost importance. Furthermore, when interviewing SANRAL, a client company, the construction contracts, as well as additional clauses to be added, were discussed. The feedback to questions were that all of the risk are carried by the contractor, with the client being concerned about the quality of the bitumen being used on site.

CHAPTER 5

RISK IDENTIFICATION FOR BITUMEN IMPORTATION

5.1 Introduction

This chapter provides a short overview of risk criteria, risk identification criteria and the risk breakdown structure, upon proceeding to the identification of the risk criteria, followed by the risks themselves. Risk identification acts as a component of the risk management sub-system. Risk identification, as previously mentioned, is believed by many to be the most important component of the risk management system, as it lays the foundation for the subsequent analysis. The section will describe the use of a risk breakdown structure, continuing to the development of a risk breakdown structure for the study at hand. The risk criteria for the risk breakdown structure was identified using ten academic sources. The identification was split into internal- and external risk, whereupon internal risk was further sub-divided into internal: local risk and internal: global risk. The risk identification was done using academic literature and semi-structured interviews, with a total of 18 different sources. The descriptions of the identified risks are stated.

5.1.1 Defining Risk Criteria

According to the ISO 31000 document, the term *Risk Criteria* refers to terms which are used to assess an organisation's risks in terms of importance or significance. The terms associated with risk criteria are used to determine whether a specified level of risk is acceptable or tolerable. Furthermore, the risk criteria of an organisation should reflect the policies, values, and objectives of both the company whilst having regards to the external views of the stakeholders. The criteria should be developed using standards, laws, policies, and other requirements (International Organization for Standardization: 31000, 2009).

5.1.2 Risk Identification Criteria

The risk criteria for the following section refers to identification criteria. The identification criteria, being discussed in this section, are the different types of risks to be identified, which are associated with the import process. The risk identification criteria can be structured hierarchically. This type of structure is referred to as a risk breakdown structure, which will be discussed in *Section 5.2*. An example of the hierarchal structure is displayed in *Figure 5.1*. The sources used for the identification of the risk criteria is stated, with each individual risk criterion being defined. Furthermore, risks will be identified for each of the individual risk criterion.

5.2 Defining Risk Breakdown Structure

Every organisation is subject to certain degree of uncertainty, known as risk. Risk stems from a variety of sources, being internal- or external of nature. Internal risks refer to risk realising from people, processes, procedures and organisational structure. External risks refer to risk realising from market conditions, industry conditions, competitors and environmental issues. As stated previously, risk management has become a key factor in the successful operation of a business or project. Risk management systems aim to minimise the threats and to maximise the opportunities, whilst maintaining focus on completing the project objectives. Various risk management systems have been developed for different implementation purposes (Hillson, 2003).

Risk management systems aim to identify and asses risks in the most effective and efficient way possible. By doing this, risks are better understood by an organisation, resulting in better management thereof. Understanding risks are the key link between the identification and assessment of risks. The understanding of risks is also the link which is least explained by guidelines. Identification as a lone procedure results in an unstructured list of risks, whereupon managers are unable to focus risk management attention. Unstructured risk identification results in risks being assessed as individual units, failing to consider patters of risk exposure, and does not provide a complete understanding of the risk faced by the project. In order to identify risk patterns, areas of risk concentrations and recurring risk themes, requires a structured approached has to be implemented (Hillson, 2003).

When dealing with large quantities of data, structuring is an essential tool for the understanding and assessment of such data. A general structuring tool is the Work Breakdown Structure (WBS) in project management. The WBS provides project managers with the ability to structure work in a systematic, hierarchal format to ensure that project objectives are met. The same can be done for risk identification. The structure is called a Risk Breakdown Structure (RBS). The RBS can be defined as source-orientated grouping which organises and defines the total risk exposure faced by a project or business. The hierarchal structure of the RBS is structured so that each descending level provides increasingly detailed information on the sources of risks. An example of a RBS structure can be seen in *Figure 5.1*. The risk breakdown structure developed for the study at hand is displayed in *Figure 5.2*, which shows the risk criteria. The RBS which includes the risk criteria, along with the identified risks can be seen in *Appendix D* (Hillson, 2003).

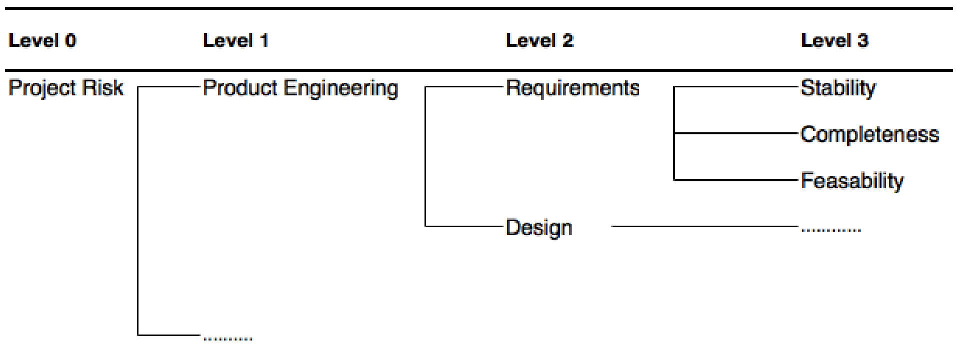

Figure 5.1: Risk Breakdown Structure Example (Hillson, 2003)

5.3 Constructing Hierarchical Risk Breakdown Structure

Different literature- and technical reports associated with the management- and identification of risks in the construction industry, as well as the international trade industry, were reviewed in this study. The review of the academic research will be approached according to the risk breakdown structure. The process starts with the identification of the risk criteria, whereupon risks will be identified for each of the corresponding criterion.

5.3.1 Identified Risk Criteria

Ten sources were reviewed for the identification of the risk criteria, the sources are (Miller, 1992:311), (Tah & Carr, 2001:835), (Zou, Zhang & Wang, 2009), (Ghosh & Jintanapakanont, 2004:633), (Baloi & Price, 2003:261), (Howell, 1994), (Wabiri & Amusa, 2011), (Martin, 2013), (Chapman, 2001:147) and (Luu, Kim, Tuan & Ogunlana, 2009:39).

Miller's (1991) study was based on creating a framework for integrated risk management in international business. In the study a four level hierarchy was developed, where the first level comprised of (1) general environmental risks, (2) industry risks and (3) firm-specific risks. The second layer comprised of 13 sub-criteria, whereupon a further 52 risks were identified for hierarchy level three and four.

Tah and Carr (2001) presented a knowledge-based approach to construction supply chain management. The studied comprised, of multi-layer hierarchy structure, of where the first level consisted of two criteria namely internal- and external risk. Internal risk consisted of a further two criteria in the third level of the hierarchy, whereas external risk consisted of four criteria. Further layers beyond the third level of the hierarchy, containing more criterion, were created.

Zou *et al.* (2009) did a study on the identification of key risks in construction projects. The study developed a two level criteria hierarchy structure, where the first level consisted of five criteria, namely (1) cost related risks, (2) time related risks, (3) quality related risks, (4) environmental related risks and (5) safety related risks. A further 51 risks were identified.

Ghosh *et al.* (2004) did a study on the identification and assessment of risk in railway construction in Thailand. The study revealed nine risk criteria, namely (1) financial and economic risk, (2) contractual and legal risk, (3) subcontractor related risk, (4) operational risk, (5) safety and social risk, (6) design risk, (7) force majeure risk, (8) physical risk and (9) delay risk.

Baloi *et al.* (2003) studied global risk factors affecting construction cost performance. The study suggested a risk breakdown hierarchy with the first level consisting of internal- and external risk, whereupon the internal risk criteria will have a sub-criteria namely organisational specific risk, and the external risk criteria will have sub-criteria namely acts of God and global risk. Further risk source criteria were identified as technical, construction, legal, natural, logistic, social, economic, financial, commercial and political risks.

Howell *et al.* (1994) only assessed one risk criterion, namely the political risk for foreign trade.

Wabiri *et al.* (2011) did a study on South Africa's crude oil import portfolio risks. The study identified two risk criteria namely (1) systematic risk and (2) specific risk. Systematic risk refers to risk event which impacts large numbers of suppliers. Specific risk refers to risk events which are specific to small groups or individual suppliers.

Martin (2013) presented at the international trade and compliance conference. In the presentation Martin (2013) identified six risk criteria namely (1) trade compliance risk, (2) environmental risk (3) labour and employment risk, (4) 3de party relationship risk, (5) health and safety risks and (6) government relationship risks.

Chapman (2001) did a study on the controlling influences on effective risk identification. The study presented a multi-level hierarchy structure, with the first level of the hierarchy consisting of four risk criteria, namely (1) environmental risks, (2) industry risks, (3) client risks, and (4) project risks.

Luu *et al.* (2008) did a study on the quantification of schedule risk. The study revealed nine risk criteria, namely (1) project related risk, (2) owner related risk, (3) contractor related risk, (4) consultant related risk, (5) design related risk, (6) material related risk, (7) workforce related risk, (8) equipment related risk, and (9) environmental related risks.

After reviewing the ten academic sources, the risk criteria regarded as most important are displayed in *Figure 5.2*.

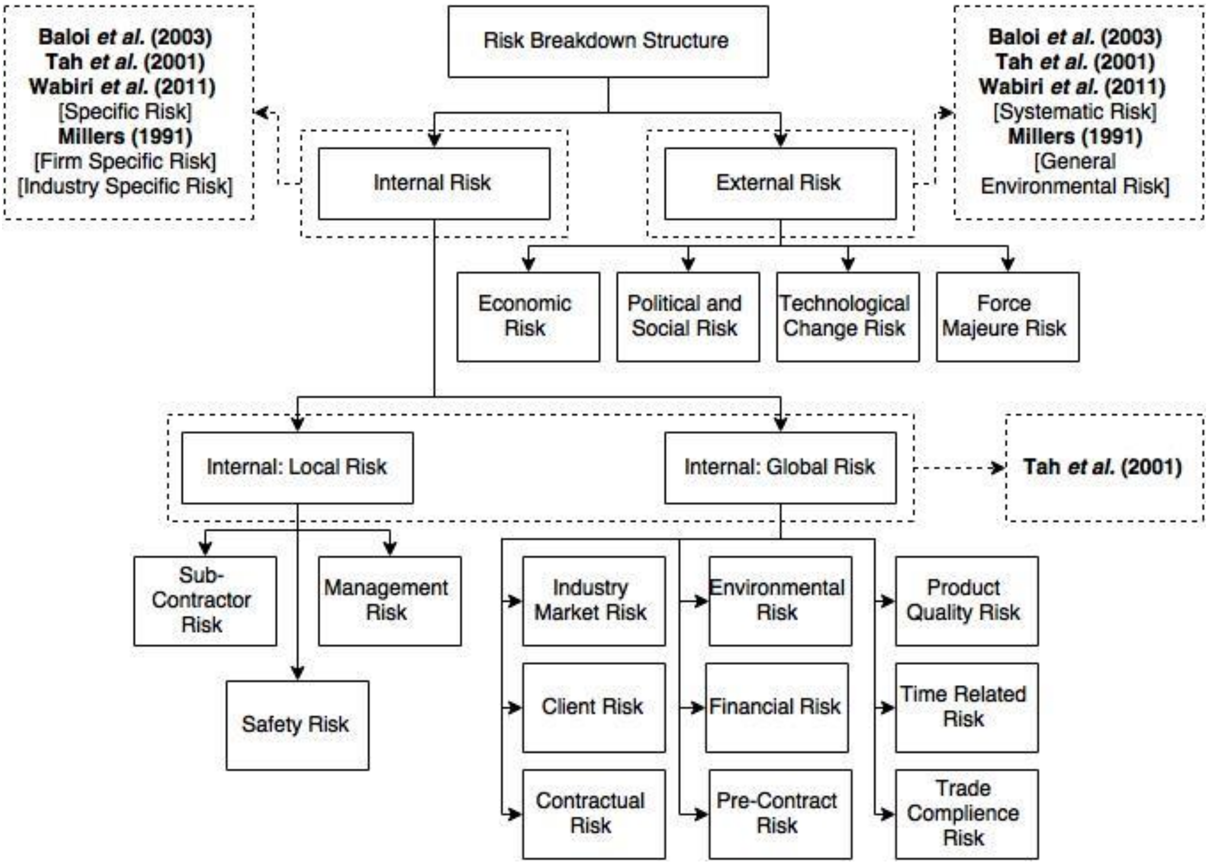

Figure 5.2: Risk Breakdown Structure stating all Risk Criteria

The following academic literature supported the selection of the risk criteria. *Table 5.1*, *Table 5.2* and *Table 6.3* displays the *External Risk* criteria, *Internal: Local Risk* criteria and *Internal: Global Risk* criteria accordingly.

Table 5.1: External Risk Criteria - Academic Literature

	External Risk			
	Economic Risk	**Political and Social Risk**	**Technological Change Risk**	**Force Majeure Risk**
Baloi *et al.* (2003)	√	√		√
Ghosh *et al.* (2004)				√
Howell (1994)		√		

Martin (2013)		√		
Miller (1991)		√		
Tah *et al.* (2001)	√	√	√	√

The following table displays the academic literature in support of the *Internal: Local Risk* criteria.

Table 5.2: Internal: Local Risk Criteria - Academic Literature

Internal: Local Risk			
	Sub-Contractor Risk	**Management Risk**	**Safety Risk**
Ghosh *et al.* (2004)	√	√	√
Martin (2013)	√	√	√
Miller (1991)		√	√
Tah *et al.* (2001)	√	√	√
Zou *et al.* (2009)			√

The following table displays the academic literature in support of the *Internal: Global Risk* criteria.

Table 5.3: Internal: Global Risk Criteria - Academic Literature

Internal: Global Risk									
	F_1	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**F_9**
Baloi *et al.* (2003)	√		√		√				
Chapman (2001)	√	√			√				
Ghosh *et al.* (2004)			√		√				
Luu *et al.* (2008)		√		√			√		
Martin (2013)				√					√
Miller (1991)	√								
Tah and Carr (2001)		√	√		√	√		√	
Zou *et al.* (2009)					√		√	√	

Where the variable $\mathbf{F_1}$ to $\mathbf{F_9}$ represent the following:

$\mathbf{F_1}$ Industry Market Risk

$\mathbf{F_2}$ Client Risk

$\mathbf{F_3}$ Contractual Risk

$\mathbf{F_4}$ Environmental Risk

$\mathbf{F_5}$ Financial Risk

$\mathbf{F_6}$ Pre-Contract Risk

$\mathbf{F_7}$ Product Quality Risk

$\mathbf{F_8}$ Time Related Risk

$\mathbf{F_9}$ Trade Compliance Risk

5.3.1.1 External Risk

According to Tah *et al.* (2001), *External Risk* refers to risk which are relatively uncontrollable. The nature of external risks are those which operate outside the boundaries of an individual company, or the construction in which it's located, and requires continual scanning and forecasting for effective risk management (Tah & Carr, 2001:835).

5.3.1.1.1 Economic Risk

Economic Risk refers to risks which influence the economic state of the international trade market. Risks associated with this criterion may include exchange rate fluctuations and inflation.

5.3.1.1.2 Political and Social Risk

Political and Social Risk refers to risks associated with the political and social state of exporting countries. Risks which may fall in this criteria includes war, exporting sanctions or population uprising.

5.3.1.1.3 Technological Change Risk

Technological Change Risk refers to risks associated with the technological stance and capability of the exporting company. Risks which may fall in the criteria includes technological superiority of exporting country, or having an exporting country which is not able to export product due technological inferiority.

5.3.1.1.4 Force Majeure Risk

Force Majeure Risk refers to risks which can be defined as *Acts of God*. Risks which may fall in the criteria include ship delays to bad weather, or unloading delays due to bad weather.

5.3.1.2 Internal: Local Risk

According to Tah *et al.* (2001), *Internal: Local Risk* refers to risk criteria which are local to individual work packages, an individual company or a category of a project (Tah & Carr, 2001:835).

5.3.1.2.1 Sub-Contractor Risk

Sub-Contractor Risk refers to risks arising from the involvement of sub-contractors. These risks would typically occur should a sub-contracting company be involved for transportation- or unloading of the bitumen product.

5.3.1.2.2 Safety Risk

Safety Risk refers to risks which could potentially influence the company personal on site, whether being at the place of unloading or at the storage destination.

5.3.1.2.3 Management Risk

Management Risk refers to risks associated with the internal logistics procedure of the import process. Example of management risks would be the internal- documentation and administration.

5.3.1.3 Internal: Global Risk

According to Tah *et al.* (2001), *Internal: Global Risk* refers to risk criteria associated with a specific project on industry scale, and cannot be limited to a particular company or work package (Tah & Carr, 2001:835).

5.3.1.3.1 Industry Market Risk

Industry Market Risk refers to risks stemming from the bitumen market. Such risks include industry market competition or decrease in demand.

5.3.1.3.2 Client Risk

Client Risk refers to risks associated with the project client. An example of this type of risk is design changes.

5.3.1.3.3 Contractual Risk

Contractual Risk refer to risks stemming from contractual obligations. An example of this type of risk is product liability uncertainty.

5.3.1.3.4 Environmental Risk

Environmental Risk refers to risks associated with damaging or pollution of the environmental system. An example of this type of risk is the spilling of the bitumen product.

5.3.1.3.5 Financial Risk

Financial Risk refers to risk associated with the funding of the import process. An example of this type of risk is the declination of a letter of credit from a financial institution.

5.3.1.3.6 Pre-Contract Risk

Pre-Contract Risk refers to risks stemming from the point of tender. A typical risk in the criterion would be the win of a tender, due to elevated costs of importing bitumen and the lowest bid tender strategy.

5.3.1.3.7 Product Quality Risk

Product Quality Risk refers to risks stemming from the bitumen product. Risks associated with this criterion include bitumen quality not being according to South Africa standards upon arrival.

5.3.1.3.8 Time Related Risk

Time Related Risk entails risk stemming from issues which would negatively influence the project schedule. An example of this type of risk is the late arrival of bitumen product.

5.3.1.3.9 Trade Compliance Risk

Trade Compliance Risk refers to risks associated with the documentation needed for the import process. An example of this type of risk is incomplete documentation for clearing customs.

5.3.2 Identified Risks for International Trade in Bitumen

The risks will be identified in accordance with the relative risk criterion. The risk identification techniques were defined in *Section 3.5.2*. The identification was done using a combination of two methods as identified by Chapman (1998), being *Identification by Risk Analyst* and *One-to-one Interviews*. The identification procedures, as stated in the literature, were used as a guideline for the physical risk identification for the bitumen import system. Risks will be identified using academic literature on international trade of bitumen, steel, general commodities and conference proceedings, as well as identification through semi-structured interviews with industry professionals. The sources used for the identification of risks are the following:

Table 5.4: Sources used for Risk Identification

Source: Author or Authors	Description of Study
Baloi *et al.* (2003)	Modelling global risk factors affecting construction cost performance
Chapman (2001)	The controlling influences on effective risk identification and assessment for construction design management.
Ghosh *et al.* (2004)	Identifying and assessing the critical risk factors in an underground rail project in Thailand: a factor analysis approach.
K.F. Kroner and W.D. Lastrapes (1993)	The impact of exchange rate volatility on international trade: reduce form estimates using the GARCH-in-mean model.
K. Louw (2015)	Interview: Engineer at COLAS
Luu *et al.* (2008)	Quantifying schedule risk in construction projects using Bayesian belief networks.
Maritime Safety (2004)	Port and Harbour Risk Assessment and Safety Management Systems
H.G. Meissner (1990)	Strategic International Marketing

Miller (1992)	A framework for integrated risk management in international business.
F. Niepman and T. Schmidt-Eisenlohr (2004)	International trade, risk, and the role of banks.
P. Rajib (2015)	International trade & risk associated with international trade.
P. Secru (2013)	Managing default risk in international trade.
B. Seyoum (2008)	Export-Import theory, practices, and procedures
Southern African Bitumen Association (SABITA) (2013)	Best practice guide for the procurement and importing of bitumen.
SunCorp Bank Australia (2015)	Managing trade risk for importers
Tah *et al.* (2001)	Towards a framework for project risk knowledge management in the construction supply chain.
United Overseas Bank (2015)	Risks in international trade and mitigation measures.
Zou *et al.* (2009)	Identifying key risk in construction projects: Life cycle and stakeholder perspectives.

5.3.2.1 External Risk

The sub-criteria for *External Risk*, as seen in *Figure 5.2*, are listed below as sub-headings. As stated previously, *External Risk* refers to risks which are relatively uncontrollable.

5.3.2.1.1 Economic Risk

The risks identified are shown in *Table 5.5*. The academic literature which was reviewed for the identification of economic risks are displayed apposite the identified risk.

Table 5.5: Identification of Economic Risks

Economic Risks Identified	Source
Inflation	(Miller, 1992:311)(Tah & Carr, 2001:835)(Zou, Zhang & Wang, 2009)(Baloi & Price, 2003:261)(Chapman, 2001:147)(Ghosh & Jintanapakanont, 2004:633)
Changes in relative price/ Price Fluctuation	(Miller, 1992:311)(Baloi & Price, 2003:261)(Luu, Kim, Tuan & Ogunlana, 2009:39)(Suncorp Bank, 2015)(Meissner, 1990:177)
Foreign exchange rates	(Miller, 1992:311)(Baloi & Price, 2003:261)(Chapman, 2001:147)(Ghosh & Jintanapakanont, 2004:633)(Kroner & Lastrapes, 1993:298)(Rajib, 2015)(United Overseas Bank, 2015)(Suncorp Bank,

	2015)(Seyoum, 2008:649)(Meissner, 1990:177)
Interest rates	(Miller, 1992:311)(United Overseas Bank, 2015)
Terms of trade	(Miller, 1992:311)(Secru, 2013)(Suncorp Bank, 2015)(Seyoum, 2008:649)
Taxation on imported product	(Baloi & Price, 2003:261)

5.3.2.1.2 Political and Social Risk

The risks identified are shown in *Table 5.6*. The academic literature which was reviewed for the identification of political and social risks are displayed apposite the identified risk.

Table 5.6: Identification of Political and Social Risks

Political and Social Risks Identified	Source
War in exporting country	(Miller, 1992:311)(Baloi & Price, 2003:261)(Ghosh & Jintanapakanont, 2004:633)
Coup d'état	(Miller, 1992:311)
Democratic changes in government	(Miller, 1992:311)
Other political turmoil	(Miller, 1992:311)(Baloi & Price, 2003:261)(Rajib, 2015)(United Overseas Bank, 2015)(Suncorp Bank, 2015)(Seyoum, 2008:649)(Meissner, 1990:177)
Price controls	(Miller, 1992:311)
Trade Restrictions	(Miller, 1992:311)
Nationalization	(Miller, 1992:311)
Government regulations	(Miller, 1992:311)(Baloi & Price, 2003:261)
Monetary reforms	(Miller, 1992:311)
Changing social concerns	(Miller, 1992:311)(United Overseas Bank, 2015)
Riots	(Miller, 1992:311)(Baloi & Price, 2003:261)
Terrorist movements	(Miller, 1992:311)(Baloi & Price, 2003:261)
Government relations	(Baloi & Price, 2003:261)

5.3.2.1.3 *Technological Change Risk*

The risks identified are shown in *Table 5.7*. The academic literature which was reviewed for the identification of technological change risks are displayed apposite the identified risk.

Table 5.7: Identification of Technological Change Risks

Technological Change Risks Identified	Source
Product innovations	(Miller, 1992:311)
Process innovations	(Miller, 1992:311)
Innovation by competitors	(Chapman, 2001:147)

5.3.2.1.4 *Force Majeure Risk*

The risks identified are shown in *Table 5.8*. The academic literature which was reviewed for the identification of force majeure risks are displayed apposite the identified risk.

Table 5.8: Identification of Force Majeure Risks

Force Majeure Risks Identified	Source
Hurricanes	(Miller, 1992:311)(Chapman, 2001:147)
Earthquakes	(Miller, 1992:311)(Chapman, 2001:147)
Other natural disasters	(Miller, 1992:311)(Chapman, 2001:147)
Bad weather on open sea	(Miller, 1992:311)(Baloi & Price, 2003:261)(Chapman, 2001:147)(Ghosh & Jintanapakanont, 2004:633)(Luu, Kim, Tuan & Ogunlana, 2009:39)(Maritime Safety, 2004)

5.3.2.2 Internal: Local Risk

The sub-criteria for *Internal: Local Risk*, as seen in *Figure 5.2*, are listed below as sub-headings. As stated previously, *Internal: Local Risk* refers to risk criteria which are local to individual work packages, an individual company or a category of a project (Tah & Carr, 2001:835).

5.3.2.2.1 *Sub-Contractor Risk*

The risks identified are shown in *Table 5.9*. The academic literature which was reviewed for the identification of sub-contractor risks are displayed apposite the identified risk.

Table 5.9: Identification of Sub-Contractor Risks

Sub-Contractor Risks Identified	Source
Low management competency of sub-contractors	(Zou, Zhang & Wang, 2009)(Luu, Kim, Tuan & Ogunlana, 2009:39)

Unavailability of skilled sub-contractors	(Zou, Zhang & Wang, 2009)(Luu, Kim, Tuan & Ogunlana, 2009:39)(Luu, Kim, Tuan & Ogunlana, 2009:39)
Lack of coordination between project participants	(Zou, Zhang & Wang, 2009)(Ghosh & Jintanapakanont, 2004:633)(Luu, Kim, Tuan & Ogunlana, 2009:39)
Sub-contractor lack of adequate equipment or staff	(Ghosh & Jintanapakanont, 2004:633)

5.3.2.2.2 *Safety Risk*

The risks identified are shown in *Table 5.10*. The academic literature which was reviewed for the identification of safety risks are displayed apposite the identified risk.

Table 5.10: Identification of Safety Risks

Safety Risks Identified	Source
Employee safety risk	(Miller, 1992:311)(Zou, Zhang & Wang, 2009)(Luu, Kim, Tuan & Ogunlana, 2009:39)
Labour unrest	(Miller, 1992:311)

5.3.2.2.3 *Management Risk*

The risks identified are shown in *Table 5.11*. The academic literature which were reviewed for the identification of management risks are displayed apposite the identified risk.

Table 5.11: Identification of Management Risks

Management Risks Identified	Source
Unavailability of sufficient professionals and managers	(Zou, Zhang & Wang, 2009)(Luu, Kim, Tuan & Ogunlana, 2009:39)
Project size and complexity	(Baloi & Price, 2003:261)
Inadequate project management controls	(Chapman, 2001:147)
Incorrect balance of resources and expertise	(Chapman, 2001:147)
Knowledge inadequacy	(United Overseas Bank, 2015)

5.3.2.3 Internal: Global Risk

The sub-criteria for *Internal: Local Risk*, as seen in *Figure 5.2*, are listed below as sub-headings. As stated previously, *Internal: Global Risk* refers to risk criteria associated with a specific project on industry scale, and cannot be limited to a particular company or work package (Tah & Carr, 2001:835).

5.3.2.3.1 *Industry Market Risk*

The risks identified are shown in *Table 5.12*. The academic literature which was reviewed for the identification of industry market risks are displayed apposite the identified risk.

Table 5.12: Identification of Industry Market Risks

Industry Market Risks Identified	Source
Changes in the quantity used by others	(Miller, 1992:311)(Chapman, 2001:147)(Meissner, 1990:177)
Shifts in market supply	(Miller, 1992:311)(Tah & Carr, 2001:835)(Chapman, 2001:147)(Meissner, 1990:177)
Availability of product from other sources	(Miller, 1992:311)(Tah & Carr, 2001:835)(Baloi & Price, 2003:261)
Scarcity in complimentary products	(Miller, 1992:311)
Rivalry among existing competitors	(Miller, 1992:311)(Baloi & Price, 2003:261)
New entrants in importing industry	(Miller, 1992:311)(Baloi & Price, 2003:261)(Chapman, 2001:147)

5.3.2.3.2 *Client Risk*

The risks identified are shown in *Table 5.13*. The academic literature which was reviewed for the identification of client risks are displayed apposite the identified risk.

Table 5.13: Identification of Client Risks

Client Risks Identified	Source
Design variations by client	(Zou, Zhang & Wang, 2009)(Ghosh & Jintanapakanont, 2004:633)
Occurrence of disputes	(Zou, Zhang & Wang, 2009)(Ghosh & Jintanapakanont, 2004:633)
General client generated risk	(Baloi & Price, 2003:261)(Ghosh & Jintanapakanont, 2004:633)
Client does not allow for adequate time for process	(Chapman, 2001:147)
Responsibilities of the client team ill defined	(Chapman, 2001:147)

5.3.2.3.3 *Contractual Risk*

The risks identified are shown in *Table 5.14*. The academic literature which was reviewed for the identification of contractual risks are displayed apposite the identified risk.

Table 5.14: Identification of Contractual Risks

Contractual Risks Identified	Source
Product liability uncertainty	(Miller, 1992:311)
Emissions and pollutants liability uncertainty	(Miller, 1992:311)
Delay in solving contractual issues	(Ghosh & Jintanapakanont, 2004:633)
General legal risks.	(United Overseas Bank, 2015)

5.3.2.3.4 Environmental Risk

The risks identified are shown in *Table 5.15*. The academic literature which was reviewed for the identification of environmental risks are displayed apposite the identified risk.

Table 5.15: Identification of Environmental Risks

Environmental Risks Identified	Source
Ecological constraints	(Chapman, 2001:147)(Ghosh & Jintanapakanont, 2004:633)
Pollution in harbour during unloading	(Ghosh & Jintanapakanont, 2004:633)

5.3.2.3.5 Financial Risk

The risks identified are shown in *Table 5.16*. The academic literature which was reviewed for the identification of financial risks are displayed apposite the identified risk.

Table 5.16: Identification of Financial Risks

Financial Risks Identified	Source
Inaccurate cost estimation	(Zou, Zhang & Wang, 2009)(Chapman, 2001:147)
Corrupt practices	(Baloi & Price, 2003:261)
Fraudulent practices	(Baloi & Price, 2003:261)(Secru, 2013)
Inadequate project funding	(Chapman, 2001:147)(Rajib, 2015)(United Overseas Bank, 2015)(Suncorp Bank, 2015)(Seyoum, 2008:649)
Timing of availability of funds	(Chapman, 2001:147)(Ghosh & Jintanapakanont, 2004:633)(Seyoum, 2008:649)
No budget for contingency measures	(Chapman, 2001:147)
Design errors	(Chapman, 2001:147)
Design quantity variations	(Luu, Kim, Tuan & Ogunlana, 2009:39)

Loss of Cargo	(Rajib, 2015)(Secru, 2013)(Suncorp Bank, 2015)(Seyoum, 2008:649)(Meissner, 1990:177)
Storage Facilities	(A. Robinson, 2015)(K. Louw, 2015)(G. Fourie, 2015)(G. Fourie, 2015; K. Louw, 2015)(G. Fourie, 2015; K. Louw, 2015)

5.3.2.3.6 *Pre-Contract Risk*

The risks identified are shown in *Table 5.17*. The academic literature which was reviewed for the identification of pre-contract risks are displayed apposite the identified risk.

Table 5.17: Identification of Pre-Contract Risks

Pre-Contract Risks Identified	Source
Unproven design solutions adopted	(Chapman, 2001:147)
Tendered price	(Ghosh & Jintanapakanont, 2004:633)(Luu, Kim, Tuan & Ogunlana, 2009:39)

5.3.2.3.7 *Product Quality Risk*

The risks identified are shown in *Table 5.18*. The academic literature which was reviewed for the identification of product quality risks are displayed apposite the identified risk.

Table 5.18: Identification of Product Quality Risks

Product Quality Risks Identified	Source
Product does not conform to specifications	(Secru, 2013)
Product undergoes viscosity changes	(K. Louw, 2015)

5.3.2.3.8 *Time Related Risk*

The risks identified are shown in *Table 5.19*. The academic literature which was reviewed for the identification of time related risks are displayed apposite the identified risk.

Table 5.19: Identification of Time Related Risk

Time Related Risks Identified	Source
Unloading delay due to machine failure	(Miller, 1992:311)
Unsuitable program planning	(Zou, Zhang & Wang, 2009)(Chapman, 2001:147)
Excessive approval procedure in administrative government departments	(Zou, Zhang & Wang, 2009)(Niepman & Schmidt-Eisenlohr, 2014)(Secru, 2013)

Attainment of correct documentation and permits	(Zou, Zhang & Wang, 2009)
Delay due to labour or equipment productivity	(Ghosh & Jintanapakanont, 2004:633)
Distance from exporting country to importing country	(Niepman & Schmidt-Eisenlohr, 2014)(Secru, 2013)
Availability of bitumen specific ports in South Africa	(SABITA, 2013)

5.3.2.3.9 Trade Compliance Risk

The risks identified are shown in *Table 5.20*. The academic literature which was reviewed for the identification of trade compliance risks are displayed apposite the identified risk.

Table 5.20: Identification of Trade Compliance Risk

Trade Compliance Risks Identified	Source
Incomplete approval and other documents	(Zou, Zhang & Wang, 2009)(United Overseas Bank, 2015)

5.4 Descriptions of Risks Identified

The following section gives a description of all the identified risks. The description of each individual risk will be stated in a systematic process, in accordance with the risk criteria as presented in the risk breakdown structure.

5.4.1 External Risk: Economic Risks

Economic Risks were defined previously in *Section 5.3.2.1.1*. The following are the risks identified for this criteria along with a description of each.

Table 5.21: External Risk: Descriptions of Economic Risks

Risk Identified	Description
Inflation	Import inflation refers to the inflation of domestic goods and services as a result of importation. This can be a result of foreign price increases or the depreciation of a country's exchange rate.
Changes in relative price/ Price Fluctuation	Price fluctuations refers to the fluctuation of international product prices due to global events, such as oil shortages, new source discovery, and the lifting of country sanctions.
Foreign exchange rates	Foreign exchange rate fluctuation can be either a positive or negative risk, from the view point of a strengthening or depreciating economy. The risk is subject to the contractual obligations of the parties involved, being the exporter, importer and financial institution.
Interest rates	Interest rate refers to the rate at which interest is paid by debtors for money obtained from creditors. An increase in inflation will generally lead to an increased interest rates.

Terms of trade	Terms of trade refers to the ratio between imported- and exported products. Thus, the amount of imported product an economy can afford per unit of exported goods.
Taxation on imported product	Import taxes are implied on goods imported into South Africa, and is calculated based on the Free on Board value.

5.4.2 External Risk: Political and Social Risks

Political and Social Risks were defined previously in *Section 5.3.2.1.2*. The following are the risks identified for this criteria along with a description of each.

Table 5.22: External Risk: Descriptions of Political and Social Risks

Risk Identified	Description
War in exporting country	War in exporting country could lead to shipping delays, or non-delivery of products.
Coup d'état	Coup d'état (French terminology) for the sudden overthrow of state.
Democratic changes in government	Democratic changes in government could lead to new legislation surrounding exports, as well as causing instability in the social structure of the exporting country.
Other political turmoil	Other political turmoil refers to general political changes which can occur. This includes the sudden change of legislation, or sudden inclusion of new legislation.
Price controls	Price controls refers to the implementation of maximum- or minimum price regulations, due to social- or political instability, on goods to be exported.
Trade Restrictions	Trade restrictions refers to the implementation of an artificial restriction on the trade of goods between two countries.
Nationalization	The risk occurs when privately owned institutions are forced into becoming public owned institutions, resulting in the possibility of sudden change in terms of cost or company policy.
Government regulations	The risk occurs when government interferes in a legal manner, resulting in anti-business regulations and laws.
Monetary reforms	Monetary reforms refers to any movement that changes the way in which money is supplied, and the economy financed, from the system which is currently implemented in that specific country.
Changing social concerns	The risk refers to the concerns of the population towards the export or import of products, in terms of economy well-being, job creation or depreciation, and government state.
Riots	Riots can pose a problem in terms of shipment delays, or worst case scenario, product loss.
Terrorist movements	Terrorist movements could lead to shipment delays, or worst case scenario, product loss.

Government relations	The risk refers to the relationship between the governments of importing- and exporting country. A bad or disintegrating relationship could have an impact on import possibility for both public- and private sector.

5.4.3 External Risk: Technological Change Risks

Technological Change Risk were defined previously in *Section 5.3.2.1.3*. The following are the risks identified for this criteria along with a description of each.

Table 5.23: External Risk: Descriptions of Technological Change Risk

Risk Identified	Description
Product innovations	Risk occurs when either a local source, or a competitive source undergoes product innovations. A result of this can be the usage of "old" product, where there might be a better product on the market.
Process innovations	Risk occurs when either a local source, or a competitive source undergoes process innovations. A result of this can be that competitor importers receive a better product in a shorter period of time.
Innovation by competitors	Risk occurs when competitors find a method for faster, more efficient or cost effective bitumen importation.

5.4.4 External Risk: Force Majeure Risks

Force Majeure Risk were defined previously in *Section 5.3.2.1.4*. The following are the risks identified for this criteria along with a description of each.

Table 5.24: External Risk: Descriptions of Force Majeure Risks

Risk Identified	Description
Hurricanes	Should exporting country be subject to regular hurricane conditions, shipping might be delayed by long periods of time. Worst case scenario could be the loss of product.
Earthquakes	Should exporting country be subject to regular earthquake conditions, shipping might be delayed by long periods of time. Worst case scenario could be the complete loss of product.
Other natural disasters	Should exporting country be subject to regular occurrence of other natural disasters, shipping might be delayed by long periods of time. Worst case scenario could be a loss of product.
Bad weather on open sea	Bad weather at sea could cause shipment delays or even the loss of product.

5.4.5 Internal: Local Risk – Sub-Contractor Risk

Sub-Contractor Risk were defined previously in Section *5.3.2.2.1*. The following are the risks identified for this criteria along with a description of each.

Table 5.25: Internal: Local Risk - Descriptions of Sub-Contractor Risks

Risk Identified	Description
Low management competency of sub-contractors	The risk occurs should sub-contractors be used for the unloading of the product upon arrival. If the management skills of the sub-contracting company is not up to standard, unloading delays might occur or even loss of product.
Unavailability of skilled sub-contractors	The unavailability of skilled sub-contractors, should sub-contractors be used, could lead to potential loss of product or unloading delays.
Lack of coordination between project participants	Sub-contractors and company representatives should work in a systematic and coordinated manner, in order to assure that little time is wasted on disputes. Should an uncoordinated relationship exist, loss of product or unloading delays could realise.
Sub-contractor lack of adequate equipment or staff	The importation of bitumen in bulk volume requires large amount of sub-contracting resources. Unavailability of resources can lead to unloading delays.

5.4.6 Internal: Local Risk – Safety Risk

Safety Risk were defined previously in Section *5.3.2.2.2*. The following are the risks identified for this criteria along with a description of each.

Table 5.26: Internal: Local Risk - Descriptions of Safety Risks

Risk Identified	Description
Employee safety risk	When unloading the product, employees may be subject to dangerous conditions such as working with hot bitumen, as well as working in close proximity to water.
Labour unrest	Importing bitumen may cause a depreciation in job creation. This, as a result, could lead to labour unrest, causing delays or product loss.

5.4.7 Internal: Local Risk – Management Risk

Management Risk were defined previously in *Section 5.3.2.2.3*. The following are the risks identified for this criteria along with a description of each.

Table 5.27: Internal: Local Risk - Descriptions of Management Risks

Risk Identified	Description
Unavailability of sufficient professionals and managers	The unavailability of experienced managers could lead to delays as coordination between parties involved could be hindered.
Project size and complexity	Should large quantities be imported at once, the project could become more complex, with more parties being involved. This could lead to delays should ineffective coordination and communication exist between parties.

Inadequate project management controls	A planned managerial procedure should be in place for successful logistic and product management.
Incorrect balance of resources and expertise	Should too little experienced personal be dedicated to the project, coordination may be effected, potentially leading to delays, ineffective logistics management or product loss.
Knowledge inadequacy	The use of a project team where little knowledge exist surrounding the import of bitumen could lead to potential logistical mistakes, financial losses, disputes and delays.

5.4.8 Internal: Global Risk - Industry Market Risk

Industry Market Risk were defined previously in *Section 5.3.2.3.1*. The following are the risks identified for this criteria along with a description of each.

Table 5.28: Internal: Global Risk - Descriptions of Industry Market Risks

Risk Identified	Description
Changes in the quantity used by others	Should more than one importer use the same supplier, with one importer using more than the other, product availability could be affected, resulting in a waiting time for bitumen.
Shifts in market supply	Market supply refers to the amount of product to be sold. Should shortages arise, market supply will decrease whilst market demand stay the same. This could lead to waiting periods.
Availability of product from other sources	Should available amount from original source decrease, without having additional sources identified as contingency, delays may occur.
Scarcity in complimentary products	Should a project require modified bitumen, and complimentary products to modify the bitumen with is scarce, project delays could arise.
Rivalry among existing competitors	The addition of rival importers could lead to competition in terms of bitumen prices.
New entrants in importing industry	New importers could lead to competition in terms of bitumen prices.

5.4.9 Internal: Global Risk - Client Risk

Client Risk were defined previously in *Section 5.3.2.3.2*. The following are the risks identified for this criteria along with a description of each.

Table 5.29: Internal: Global Risk - Descriptions of Clients Risks

Risk Identified	Description
Design variations by client	Design variations to project bitumen specifications can lead to complications if imported bitumen does not conform.
Occurrence of disputes	Should the import project be a public-private partnership, disputes between the clients and importing party may arise. Disputes in a

	purely private project could also arise, should the client not approve of imported bitumen product.
General client generated risk	General client risk refers to client involvement in import process, in terms of logistics management.
Client does not allow for adequate time for process	The occurrence of a local bitumen shortage, may result in clients being reluctant to approve of additional time for the import process.
Responsibilities of the client team ill defined	The involvement of the client, if responsibilities are ill defined, could lead to disputes.

5.4.10 Internal: Global Risk - Contractual Risk

Contractual Risk were defined previously in *Section 5.3.2.3.3*. The following are the risks identified for this criteria along with a description of each.

Table 5.30: Internal: Global Risk - Descriptions of Contractual Risks

Risk Identified	Description
Product liability uncertainty	Since more than one party is involved when importing bitumen, contracts should clearly state which party carries liability at what stage of the import process.
Emissions and pollutants liability uncertainty	Emissions and pollutants liability should be stated in the contract documentation, including who carries the liability at what stage of the import process.
Delay in solving contractual issues	Contractual issues can be large source of disputes. Should the disputes not be solved within a given period of time, delays might occur.
General legal risks	The risk refers to legal actions that can be taken against the importer should health, safety and environmental laws be ignored or implemented incorrectly. The risk also allows for all legal risk the company can face.

5.4.11 Internal: Global Risk - Environmental Risk

Environmental Risk were defined previously in *Section 5.3.2.3.4*. The following are the risks identified for this criteria along with a description of each.

Table 5.31: Internal: Global Risk - Descriptions of Environmental Risks

Risk Identified	Description
Ecological constraints	Ecological constraints refer to the maximum amount of resources to be gained from the planet. Reaching the limit of constraints could lead to fines, or shortages.
Pollution in harbour during unloading	Upon unloading, due to no bitumen specific port in South Africa, external equipment have to be used. This creates an environment

	where spilling of product, or other forms of pollution, could occur which could lead to fines or delays.

5.4.12 Internal: Global Risk - Financial Risk

Financial Risk were defined previously in *Section 5.3.2.3.5*. The following are the risks identified for this criteria along with a description of each.

Table 5.32: Internal: Global Risk - Descriptions of Financial Risks

Risk Identified	Description
Inaccurate cost estimation	Inaccurate cost estimation of the bitumen import system could lead to additional costs.
Corrupt practices	Corrupt export-, shipping- or third party corporations could result in poor quality bitumen product, late arrival of bitumen product, non-arrival of product or general financial losses.
Fraudulent practices	Fraudulent export-, shipping- or third party corporations could result in poor quality bitumen product, late arrival of bitumen product, non-arrival of product or general financial losses.
Inadequate project funding	Should funding for the import process be lacking, additional costs might be incurred.
Timing of availability of funds	Late funding from financial institutions could lead to delays, additional costs or contract breaches.
No budget for contingency measures	No budget for contingency measures could lead to the importing firm having to pay large monetary sums, using money which is not available at that point in time.
Design errors	Project design errors could lead to unusable batch of bitumen being imported resulting in losses or delays.
Quantity variations	Should bitumen quantity needed be miscalculated, additional bitumen need to be sourced, resulting in additional costs and delays.
Loss of Cargo	Loss of cargo due to any reason will have financial or time associated implications. Risk ownership is important for such a scenario.
Storage Facilities	Inadequate storage facilities could lead to additional facility hire. For large quantities, the additional hire costs will be high.

5.4.13 Internal: Global Risk - Pre-Contract Risk

Pre-Contract Risk were defined previously in *Section 5.3.2.3.6*. The following are the risks identified for this criteria along with a description of each.

Table 5.33: Internal: Global Risk - Descriptions of Pre-Contract Risks

Risk Identified	Description
Unproven design solutions adopted	Unproven design solution refers to solutions implemented to ease the import process or unloading process. Should the solution not work it could cause delays or financial losses.
Tendered price	Using imported bitumen is more expensive than locally sourced bitumen. With the tender structure working on a lowest bid process, tenders might not be awarded.

5.4.14 Internal: Global Risk - Product Quality Risk

Product Quality Risk were defined previously in *Section 5.3.2.3.7*. The following are the risks identified for this criteria along with a description of each.

Table 5.34: Internal: Global Risk - Descriptions of Product Quality Risks

Risk Identified	Description
Product does not conform to specifications	The non-conformant of the bitumen product, whether at the international refinery or at destination location could have large implications in terms delays and financial losses.
Viscosity changes of bitumen during transport	During the transportation section of the import system, bitumen can undergo viscosity changes in terms of hardening and softening.

5.4.15 Internal: Global Risk - Time Related Risk

Time Related Risk were defined previously in *Section 5.3.2.3.8*. The following are the risks identified for this criteria along with a description of each.

Table 5.35: Internal: Global Risk - Descriptions of Time Related Risks

Risk Identified	Description
Unloading delay due to machine failure	Machine failure in the unloading process could cause delays, and as such financial losses.
Unsuitable program planning	Unsuitable program planning refer to the shipment and unloading program, which if miss calculated, could further down the process cause delays and financial losses.
Excessive approval procedure in administrative government departments	Should the approval of import documentation take longer than expected, delays will occur which could result in contract breach or financial losses.
Attainment of correct documentation and permits	The attainment of all the correct documentation takes time. If miss calculated, delays will occur early in the import process.
Delay due to labour or equipment productivity	Unproductive labour and inefficient equipment could cause unloading delays, resulting in financial losses.

Availability of bitumen specific ports in South Africa	Without bitumen specific ports, external unloading systems will have to constructed. This could lead to potential time delays if not constructed correctly. Furthermore, the construction of the unloading systems will require additional funding.

5.4.16 Internal: Global Risk - Trade Compliance Risk

Trade Complience Risk were defined previously in *Section 5.3.2.3.9*. The following are the risks identified for this criteria along with a description of each.

Table 5.36: Internal: Global Risk - Descriptions of Trade Compliance Risks

Risk Identified	Description
Incomplete approval and other documents	Incomplete documentation could lead to non-approval of import documentation, causing delays and financial losses.

5.5 Verification for Identified Risks

The identified risks were presented to both Mr. Fourie and Mr. Schafer for consideration. Both professionals deemed the identified risks correct and accurate. The identification of more specific risks during the bitumen import process could however not be identified due to intellectual property surrounding the topic.

5.6 Conclusion

The chapter was aimed at the identification of risks involved for the import process of bitumen. The chapter was compiled using data obtained from academic literature, as well as semi-structured interviews with industry professionals. The aim of the risk identification process was to develop a risk checklist, in the form of a risk breakdown structure, complete with descriptions. The RBS was defined as the source-orientated grouping, which organises and defines the total risk exposure, faced by a project or business. The RBS is a hierarchal structure, as seen in *Figure 5.2*, consisting of risk criteria and furthermore identified risks. For the identification of the various risk criteria, 10 sources were analysed. The first level of the RBS consisted of external and internal risk, where upon internal risk was further sub-divided in to global and local risks. From this point the risk identification could commence. The process was completed using the guidelines stated in *Chapter 3*. In total, 75 risks were identified and described. The identification of the risks revealed three significant risks. The first is the unstable global economy which could lead to price fluctuation. As such, tender price adjustment formulae were researched. Mr. Myburgh's bitumen price index (BPI), as well as the increased cost adjustment (ICA) formula, is explained in *Appendix E*. The ICA formula is subject to use for both locally and internationally sourced bitumen. Furthermore, the second risk which was stressed during interviews is the storage facilities. The final significant risk is the viscosity changes of the bitumen. A summary of the bitumen viscosity changes, as experienced during the import of bitumen, can be seen in *Appendix F*.

CHAPTER 6

RISK ANALYSIS FOR BITUMEN IMPORTATION

6.1 Introduction

The chapter provides short description of the risk analysis scope to be taken into account, after which the fuzzy logic implementation methodology, risk quantification criteria and risk quantification by participants are defined. Following this will be the risk analysis for the study at hand. The risk analysis scope states how risks will be quantified, as well as justifying certain methodological decisions which were made for the risk analysis. The fuzzy logic methodology will be explained in a systematic manner which will indicate how the risk analysis will be performed. The risk quantification will be divided into two separate sections, being the risk quantification by the analyst and the risk quantification by an industry professional. The risk analysis will then be performed, with the required outcome being the ranking of the risks in terms of significance.

6.2 Risk Analyses Scope

The risk analysis will be based on a fuzzy logic methodology. The justification for using the fuzzy logic methodology was explained previously in *Section 3.6*. The fuzzy logic model will constructed as was done in the study done by Lu *et al.* (2014). Furthermore, the data collected for the fuzzy logic risk assessment is in the form of quantified risks. The risks will be quantified through an occurrence likelihood and degree of impact rating. Occurrence likelihood refers to the likelihood of a risk occurring. The degree of impact refers to the impact magnitude, being the financial implications thereof. The quantification criteria will be discussed in *Section 6.4*.

The quantification of the risks will be performed by two participants as stated in *Chapter 1* and *Chapter 2*. The first participant will be the analyst himself, with the second participant being an internationally based industry professional. The quantification by the analyst will be performed by means of expert judgement, based on referenced academic literature and semi-structured interviews. Each individual risk will be analysed and researched individually, whereupon the risk will be quantified. The semi-structured interviews were not specifically directed at the quantification of risks, as intellectual property surrounding the risks exist (M. Schafer, 2015). As such, data collected during interviews, with reference to certain risks, will be taken into account during the quantification process. All additional risks, not mentioned during interviews, will be researched. The quantification performed by the internally based professional, being Mnr. Fourie from Australia, is there to give (1) an international, and professional, perspective on bitumen import risk, and (2) to provide a secondary data set for the fuzzy logic risk analyses. The interview with Mr. Fourie is shown in *Appendix A*. The data gathered for the risk quantification is stated later in *Section 6.5*.

The risk assessment is performed to be indicative. This is due to time limitations, as well as lack of experienced bitumen importers in South Africa. As previously stated, only one company has successfully imported bitumen into South Africa. As such, intellectual property exist surrounding certain risk criteria. It will be stated later in *Chapter 8,* that for this study to be more authoritative, a largely quantitative-based study is required in addition to the study at hand. The additional study should use more participants, whether locally- or internationally-based, to get a better understanding of the associated risks.

6.3 Using a Fuzzy Based Multi-Criteria Decision Model

When making real life decisions, decision makers have to take various criteria into account (Kriel, 2013). The study will be performed using a combination of fuzzy based multi-criteria decision models as presented by Chou *et al.*, and Lu, Yu and Chang (Chou, Chou & Tzeng, 2006:1026)(Lu, Yu & Chang, 2014). The model uses the initial fuzzy logic planning process, as implemented by Chou *et al.*, and continues to use the model design of Lu *et al.* The step-wise methodology is presented by *Table 6.1*.

Table 6.1: Fuzzy Based Heuristic Model Step-Wise Methodology (Chou, Chou & Tzeng, 2006:1026)(Lu, Yu & Chang, 2014)

Steps	Description
Step 1	Identify a weighing and scoring team
Step 2	Fuzzy number selection
Step 3	Definition of the linguistic variables and quantification criteria
Step 4	Heuristic Model Risk Quantification Criteria
Step 5	Determining the degree of impact of risk factors
Step 6	Determining the occurrence likelihood of risk factors
Step 7	Determining global fuzzy weights of criteria

6.3.1 Identify a Weighting and Scoring Team

When performing a fuzzy logic based risk analysis, different researchers have had different strategies towards the logistics surrounding the group of individuals who constitute the weighing and the scoring team. Chou, Chou and Tzeng (2006) used two exclusive teams in their study to perform the weighing of the criteria and the scoring of the alternatives separately. However, the study performed by Chou *et al.* (2006) was not to score risks with the aim of ranking them, but rather for decision making purposes in terms of choosing between two products. The teams used for the study comprised of individuals from different sectors of the organisation. It is stated in the article that the authors did this in order to see where the priorities lie when analysing different members making up the stakeholder group (Chou, Chou & Tzeng, 2006:1026).

In the study performed by Lu *et al.* (2014), the fuzzy logic methodology on which the current assessment is based, the researchers used one group for all the processes regarding the fuzzy logic assessment procedure. The researchers selected to use 23 professionals, with experience in railway construction in Taiwan, to quantify identified risks in terms of probability and impact. The risks were initially identified through means of interviews with some of the 23 professionals. The 23 selected professionals were then asked to rate the risks in terms of probability and impact. According to the article, the 23 experts comprised of 18 males and five females, in which seven of the 23 had experience between 10 to 15 years, eleven had experience of 15 to 20 years and five of the experts had experience of above 20 years. The professionals were asked to rank the risks using the linguistic variables, which will be explained later in *Section 6.2.3* (Lu, Yu & Chang, 2014).

6.3.2 Fuzzy Number Selection

According to Dubois and Prade, a fuzzy number can be defined as a fuzzy sub-set of the crisp or real value line, whereupon the highest values of the membership function are grouped around a central value called the mean value. Furthermore, when using the term membership function, it refers to a graphical representation of a fuzzy number, with both sides of the membership function being uniform on both sides of the mean values (Dubois & Prade, 1978). *Figure 6.1* gives a representation of a membership function associated with a fuzzy number. The study done by Lu *et al.* (2014) used a trapezoidal fuzzy number distribution. The reason for using a trapezoidal distribution compared to a triangular distribution, is due to several reasons. The first reason for using trapezoidal fuzzy numbers are because of a study performed by Gajivaradhan and Parthiban (2015), where the researched statistical hypothesis testing through trapezoidal fuzzy interval data. In this study it was stated that trapezoidal fuzzy numbers are regarded as the most commonly used from all fuzzy numbers associated with the linear membership function class. Furthermore, Gajivaradhan *et al.* stated that triangular fuzzy membership functions originated from the trapezoidal membership function, with the trapezoidal membership functions being implemented mostly when modelling linear uncertainty in either scientific or applied engineering problems, modelling fuzzy transportation problems and modelling ranking problems (Gajivaradhan & Parthhiban, 2015).

Miao, Hammel, Hanratty and Tang (2014) researched the comparative aspects of fuzzy membership functions for the determination of the value of information. The study originated from the data overloading in the military sector of America, where the researchers tried to assign a value to information in order to make searching for a specific data an easier process. The study made use of both triangular and trapezoidal membership functions for the comparison process. In this study it was revealed that using trapezoidal membership functions provides researchers more flexibility (Miao, Hammel, Hanratty & Tang, 2014:53). Furthermore, a study performed by Botzheim, Hamori and Koczy (2001) on the optimisation of trapezoidal membership functions in a fuzzy rule system by the "backterial algorithm" approach, stated that by using trapezoidal fuzzy numbers, researchers will have less complex rules to implement as appose to using triangular fuzzy numbers. This being said, in a study performed by Shapiro and Koissi (2015) who used triangular fuzzy numbers for their risk analysis, as they modelled the risk procedures from a study performed by Wu, Cheng, Hu and Zhou (2013) (Botzheim, Hamori & Koczy, 2001)(Shapiro & Koissi, 2015). Also, a study performed by Wang and Chang (1995) used triangular membership functions, however, in the study the problem included selection. Another study performed by Chou *et al.* (2006), a triangular distribution was used for the membership function, with the problem being a decision making problem and not a ranking problem (Chou, Chou & Tzeng, 2006:1026).

As previously stated, this study is based on a risk analysis performed by Lu *et al.* (2014) for the construction of railway infrastructure in Taiwan. The study, as performed by Lu et al. uses trapezoidal fuzzy numbers, in conjunction with what is stated above, the study at hand will be performed using trapezoidal fuzzy numbers. As previously mentioned, fuzzy numbers can be seen as a sub-set of real numbers, thus representing the expansion of the idea of the confidence interval.

As such, trapezoidal fuzzy numbers should possess the following properties. If Ã represents a trapezoidal fuzzy number, the membership function of Ã is represented by *Equation (2)* and *(3)* (Lu, Yu & Chang, 2014):

$$\mu_{\tilde{A}}(x) : X \rightarrow [0,1] \tag{2}$$

Which is equal to:

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x \leq a_1 \, or \, x \geq a_4, \\ \dfrac{(x-a_1)}{(a_2-a_1)}, & a_1 \leq x \leq a_2, \\ \dfrac{(a_4-x)}{(a_4-a_3)}, & a_3 \leq x \leq a_4, \\ 1, & a_2 \leq x \leq a_3. \end{cases} \tag{3}$$

And is represented as shown in *Figure 6.1*.

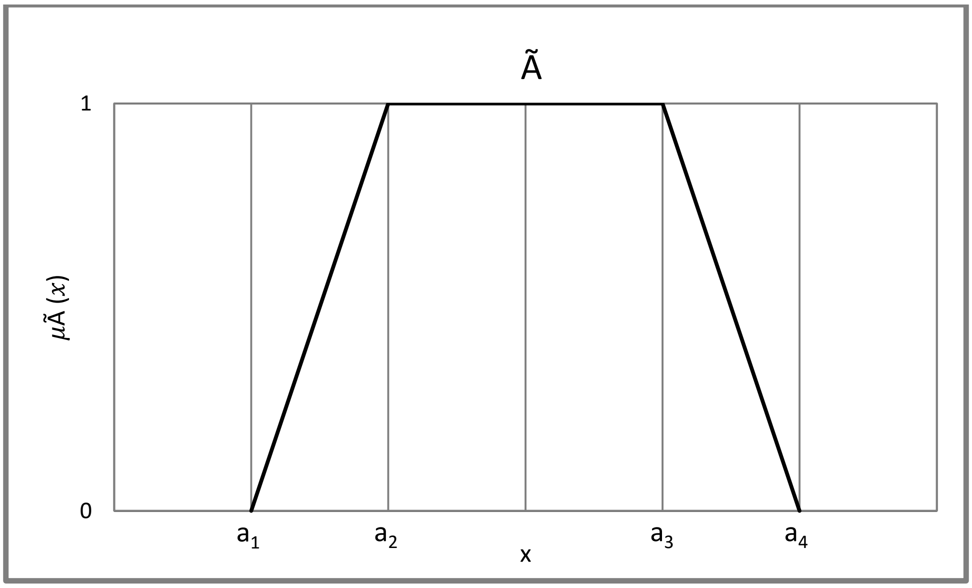

Figure 6.1: The membership function representing the trapezoidal membership function

The trapezoidal fuzzy number can be denoted by $\tilde{A} = (a_1, a_2, a_3, a_4)$, where $a_1 \leq a_2 \leq a_3 \leq a_4$, respectively. Furthermore, it can also be stated that a_1 and a_4 are the lower and upper boundaries of Ã. *Figure 6.1* provides a representation of the membership function, depicting that $a_1 \leq a_2 \leq a_3 \leq a_4$ as well as that a_1 and a_4 are the lower- and upper boundaries respectively. This being said, when performing calculations involving more than one fuzzy number set, certain rules have to be applied. When introducing a second fuzzy set denoted by $\tilde{B} = (b_1, b_2, b_3, b_4)$, where $b_1 \leq b_2 \leq b_3 \leq b_4$, and where b_1 and b_4 represent the lower and upper boundaries respectively, *Equation (4)* to *(8)* displays operational rules associated with the fuzzy analyses procedure. All equations were gained from the study done by Lu *et al.* (Lu, Yu & Chang, 2014).

Adding fuzzy numbers:

$$\tilde{A} + \tilde{B} = (a_1, a_2, a_3, a_4) + (b_1, b_2, b_3, b_4) \\ = (a_1 + b_1, a_2 + b_2, a_3 + b_3, a_4 + b_4) \tag{4}$$

Subtracting fuzzy numbers:

$$\tilde{A} - \tilde{B} = (a_1, a_2, a_3, a_4) + (b_1, b_2, b_3, b_4) \\ = (a_1 - b_1, a_2 - b_2, a_3 - b_3, a_4 - b_4) \tag{5}$$

Multiplication of fuzzy numbers:

$$\tilde{A} \times \tilde{B} = (a_1, a_2, a_3, a_4) \times (b_1, b_2, b_3, b_4) \\ = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3, a_4 \times b_4) \tag{6}$$

Division of fuzzy numbers:

$$\tilde{A} \div \tilde{B} = (a_1, a_2, a_3, a_4) \div (b_1, b_2, b_3, b_4) \\ = (a_1 \div b_4, a_2 \div b_3, a_3 \div b_2, a_4 \div b_1) \tag{7}$$

Reciprocal of a fuzzy number:

$$\tilde{A}^{-1} = \left(\frac{1}{a_1}, \frac{1}{a_2}, \frac{1}{a_3}, \frac{1}{a_4}\right) \tag{8}$$

6.3.3 Defining the Linguistic Variables

Zadeh stated in a study done on the concept of linguistic variables and the application thereof to approximate reasoning, that it is difficult to use crisp or direct quantifying values in an environment which is mostly vague or fuzzy (Zadeh, 1975:199). The linguistic variables which will be used, is a mechanism to transform crisp values to a word or sentence in human language. As such, when stating a crisp values in terms of a linguistic variable, a larger range of values are included in order to compensate for the vagueness of the environment. *Table 6.2* provides a description of the linguistic variables, as a seven semantic scale mechanism, which was used for the degree of impact quantification, in the study done by Lu *et al.* (2014). Furthermore, *Table 6.3* gives a second seven semantic scale mechanism used for the occurrence likelihood quantification in the study done by Lu *et al.* (2014). A graphical representation of the linguistic variable is displayed in *Figure 6.2*.

Table 6.2: Linguistic scales associated with the degree of impact

Semantic Scale		Corresponding Trapezoidal Fuzzy Number
Absolutely Serious	(AS)	(0.8,0.9,1.0,1.0)
Very Serious	(VS)	(0.7,0.8,0.8,0.9)
Serious	(S)	(0.5,0.6,0.7,0.8)
Average	(A)	(0.4,0.5,0.5,0.6)
Unserious	(US)	(0.2,0.3,0.4,0.5)
Very Unserious	(VUS)	(0.1,0.2,0.2,0.3)

Absolutely Unserious	(AUS)	(0.0,0.0,0.1,0.2)

Table 6.3 represents the linguistic scales to be used for the quantification of the occurrence likelihood. As stated previously, the table contains a seven semantic linguistic scale with its associated fuzzy numbers. *Figure 6.2* shows a representation of the membership functions for the linguistic scale with associated fuzzy numbers. The same fuzzy number membership functions are used for both the impact likelihood and the occurrence likelihood. Using the same seven semantic scale for the linguistic variables allows for easier conversion between crisp values and linguistic variables (Lu, Yu & Chang, 2014).

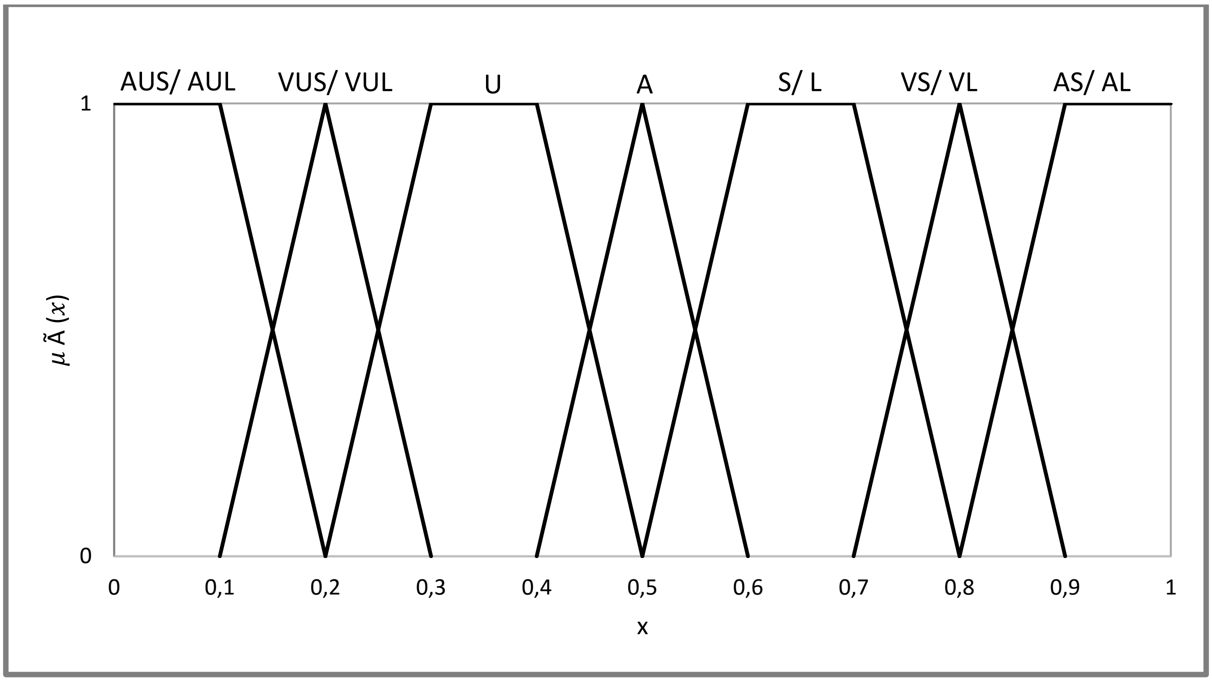

Figure 6.2: Membership functions associated with the occurrence likelihood and degree of impact linguistic variables (Lu, Yu & Chang, 2014)

The following is a representation of the linguistic scales associated with the occurrence likelihood, as used in the study of Lu *et al.* (2014).

Table 6.3: Linguistic scales associated with the occurrence likelihood

Semantic Scale		**Corresponding Trapezoidal Fuzzy Number**
Absolutely Likely	(AL)	(0.8,0.9,1.0,1.0)
Very Likely	(VL)	(0.7,0.8,0.8,0.9)
Likely	(L)	(0.5,0.6,0.7,0.8)
Average	(A)	(0.4,0.5,0.5,0.6)
Unlikely	(UL)	(0.2,0.3,0.4,0.5)
Very Unlikely	(VUL)	(0.1,0.2,0.2,0.3)
Absolutely Unlikely	(AUL)	(0.0,0.0,0.1,0.2)

6.3.4 Determining the Degree of Impact of Risk Factors

When performing fuzzy number calculations, a systematic approach has to be taken. Upon the completion of the rating procedure done by professionals, of both the degree of impact and the occurrence probability, the fuzzy rating sets is placed in a matrix form in order to perform necessary calculations. The matrix, entitled $\tilde{X}$, for the degree of impact of each of the risk factors $(F_j, j = 1, 2, 3, \ldots, n)$, as rated by professionals, is displayed by *Equation 9*. Furthermore, the x – axis of the matrix layout represents the subjective judgements of the industry professionals, of the degree of impact for each of the risks identified (Lu, Yu & Chang, 2014).

$$\tilde{X} = \begin{array}{c} \\ F_1 \\ F_2 \\ F_3 \\ \vdots \\ F_n \end{array} \begin{array}{c} \begin{array}{ccccc} E^1 & E^2 & E^3 & \cdots & E^m \end{array} \\ \begin{pmatrix} \tilde{x}_1^1 & \tilde{x}_1^2 & \tilde{x}_1^3 & \cdots & \tilde{x}_1^m \\ \tilde{x}_2^1 & \tilde{x}_2^2 & \tilde{x}_2^3 & \cdots & \tilde{x}_2^m \\ \tilde{x}_3^1 & \tilde{x}_3^2 & \tilde{x}_3^3 & \cdots & \tilde{x}_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{x}_n^1 & \tilde{x}_n^2 & \tilde{x}_n^3 & \cdots & \tilde{x}_n^m \end{pmatrix} \end{array} \tag{9}$$

$$i = 1, 2, 3, \cdots, m; j = 1, 2, 3, \cdots, n$$

In the equation above, *m* denotes the number of professionals associated with the quantification process, and *n* the number of risks identified. The variable $\tilde{x}_j^i$ is used to indicate the degree of impact as a fuzzy set, thus $\tilde{x}_j^i = (a_{1\ j}^i, a_{2\ j}^i, a_{3\ j}^i, a_{4\ j}^i)$, where *i* indicates the number of the evaluator and *j* being the number of the identified risk. Furthermore, the indicators *E* and *F* are used, where *E* indicates the same number of evaluators, being $(E^i, i = 1,2, \ldots, m)$ and *F* the same number of risks identified, being $(F^j, j = 1,2, \ldots, n)$ (Lu, Yu & Chang, 2014).

6.3.5 Determining the Occurrence Likelihood of Risk Factors

For the occurrence likelihood, the same principles apply as that of which were applied to the degree of impact matrix. When implying the linguistic scales, as done for the degree of impact, the results are placed in table format. The decision matrix representing the occurrence likelihood, denoted $\tilde{Y}$, is displayed by *Equation 10* (Lu, Yu & Chang, 2014).

$$\tilde{Y} = \begin{array}{c} \\ F_1 \\ F_2 \\ F_3 \\ \vdots \\ F_n \end{array} \begin{array}{c} \begin{array}{ccccc} E^1 & E^2 & E^3 & \cdots & E^m \end{array} \\ \begin{pmatrix} \tilde{y}_1^1 & \tilde{y}_1^2 & \tilde{y}_1^3 & \cdots & \tilde{y}_1^m \\ \tilde{y}_2^1 & \tilde{y}_2^2 & \tilde{y}_2^3 & \cdots & \tilde{y}_2^m \\ \tilde{y}_3^1 & \tilde{y}_3^2 & \tilde{y}_3^3 & \cdots & \tilde{y}_3^m \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{y}_n^1 & \tilde{y}_n^2 & \tilde{y}_n^3 & \cdots & \tilde{y}_n^m \end{pmatrix} \end{array} \tag{10}$$

$$i = 1, 2, 3, \cdots, m; j = 1, 2, 3, \cdots, n$$

In the equation above, as for the impact likelihood, *m* denotes the number of professionals and *n* the number of risks. The variable $\tilde{y}_j^i$ is used to indicate the occurrence likelihood as a fuzzy set, thus $\tilde{Y}_j^i = (a_{1\ j}^i, a_{2\ j}^i, a_{3\ j}^i, a_{4\ j}^i)$, where *i* indicates the number of the evaluator and *j* being the number of the identified risk. Also, as was done for the matrix of the degree of impact, the indicators *E* and *F* are used, where *E* indicates the same number of evaluators, being $(E^i, i = 1,2, \dots, m)$ and *F* the same number of risks identified, being $(F^j, j = 1,2, \dots, n)$ (Lu, Yu & Chang, 2014).

6.3.6 Determining Global Fuzzy Weights of Criteria

The local and global fuzzy weights of the criteria refers to general ranking of the risks, upon completion of the calculations associated with the fuzzy logic analysis procedure. In order to determine the global ranking of each of the individual risks, the calculations are performed separately for the degree of impact and occurrence likelihood, whereupon they will be combined in the last calculation step. The mathematical procedures are completed in the step wise manner, as was done in the study of Lu *et al.* The four steps to be followed are (Lu, Yu & Chang, 2014):

Step 1: Determine the synthesized value for each individual risk, which incorporates the fuzzy quantification provided by all of the evaluators, for that specific risk. This must be done for both the degree of impact as well as the occurrence likelihood.

Step 2: Implement de-fuzzification in order to achieve the best non-fuzzy performance (BNP) values. This process will be conducted using the de-fuzzification method known as the centroid method. Furthermore, the BNP values must be calculated for both the degree of impact as well as the impact likelihood.

Step 3: Determine the global weights for the risks in the degree of impact category. This calculation is performed by determining each individual risk weight in comparison to all the risks, from all risk identification criterion.

Step 4: Determine the overall degree of risk. This process will be completed using the global weights of the degree of impact category and the BNP values obtained from occurrence likelihood category.

6.3.6.1 Step 1: Determine the synthesized value for each individual risk

Each of the identified risks were evaluated by industry professionals, with each of the professionals providing a fuzzy risk score for each individual risk. As such, for each of the individual risks, various fuzzy sets exist. In order to obtain a synthesized value, including all the individual evaluations for each individual risk, *Equation 11* was implemented. This process was followed for both the occurrence likelihood as well as for the degree of impact risk evaluations. The synthesized value, denoted as $\tilde{P}_j$, was obtained as follows (Lu, Yu & Chang, 2014):

$$\tilde{P}_j = \frac{1}{m}\left[\sum_{i=1}^{m} \tilde{y}_j^i\right] \tag{11}$$

Where $\tilde{P}_j = (a_{1\,j}, a_{2\,j}, a_{3\,j}, a_{4\,j})$ represents the synthesized fuzzy set obtained from the ratings of all the evaluators, regarding the j^{th} risk factor. As such, a synthesised value should be obtained for all risks, for both occurrence likelihood and degree of impact (Lu, Yu & Chang, 2014).

6.3.6.2 Step 2: Implementation of de-fuzzification

Upon calculating the synthesized value associated with each risk, the step known as de-fuzzification has to be implemented. The reason for implementation is owing to the fact that the synthesized value is still in fuzzy set format, upon which it has to be transformed into a crisp value for ranking purposes. The BNP value has to be obtained for the occurrence likelihood- and the degree of impact synthesized values. Furthermore, the de-fuzzification formula to be implemented is known as the centroid method (Lu, Yu & Chang, 2014). According to Nurcahyo, Shumsuddin and Alias, the centroid method is one of the most commonly used de-fuzzification techniques. This method determines the centre of the area of the combined membership functions (Nurcahyo, Shamsuddin & Alias, 2013:22). In order to obtain the crisp value (w_j) associated with each of the individual synthesised fuzzy numbers $(\widetilde{w}_j)$, *Equation 11* has to be implemented. The proof of the formula is as follows (Lu, Yu & Chang, 2014):

$$\begin{aligned} w_j &= \frac{\int_{a_1}^{a_4} x \times \mu_{\overline{w}}(x)dx}{\int_{a_1}^{a_4} \mu_{\overline{w}}(x)dx} \\ &= \left(\int_{a_1}^{a_2} \frac{x(x-a_1)}{(a_2-a_1)}dx + \int_{a_2}^{a_3} x\,dx + \int_{a_3}^{a_4} \frac{x(a_4-x)}{(a_4-a_3)}dx\right) \times \\ &\quad \left(\int_{a_2}^{a_2} \frac{x(x-a_1)}{(a_2-a_1)} + \int_{a_2}^{a_3} x\,dx + \int_{a_4}^{a_4} \frac{x(a_4-x)}{(a_4-a_3)}dx\right)^{-1} \\ &= \frac{a_3^2 + a_4^2 + a_3 \times a_4 - a_1^2 - a_1^2 - a_1 \times a_2}{3(a_3 + a_4 - a_1 - a_2)} \end{aligned} \tag{12}$$

6.3.6.3 Step 3: Determine degree of impact global weights

The calculations for *Step 3* does not involve complex equations, but is rather a small step towards the complete ranking of all the risks involved in the study. *Step 3* involves only the degree of risk, where the global weights of the risks, in terms of degree of impact, will be calculated. Thus, all the risks will be ranked against one-another, only in terms of degree of impact. For calculation purposes, *Equation 13* represents the equation used for determining the global weights of the risks identified, in terms of degree of impact. The equation takes each individual risk, noted as w_j, and divides it by the sum of all the risk BNP values. This global weight of each risk is stated to be the normalised value of each risk, according to Lu *et al.* When calculating the sum of all the normalised values associated with each of the individual risks, the value obtained should be equalled to one. As such *Equation 12* looks as follows (Lu, Yu & Chang, 2014):

$$R_j = \frac{w_j}{\sum_{j=1}^{n} w_j}, \qquad \text{Where} \qquad \sum_{j=1}^{n} R_j = 1. \tag{13}$$

6.3.6.4 Step 4: Determine combination global weights of all identified risks

In the final step of the fuzzy logic risk analysis, the overall rank of all the individual risks are calculated. The step is done using *Equation 14*, where K_j represents the overall *Degree of Risk*, thus presenting the risk in terms of a combination between degree of impact and occurrence likelihood. The normalised value of the degree of impact, calculated in *Step 3* and denoted by R_j, is multiplied by the BNP value of the occurrence likelihood. This process is done for each individual risk, with the BNP value of the occurrence likelihood being denoted by P_j. *Equation 14* is as follows (Lu, Yu & Chang, 2014):

$$K_j = R_j \times P_j \tag{14}$$

6.4 Risk Analysis Results

The following section presents the risk analysis performed for the research study. The section will state the risk quantification by both participants, for both degree of impact (DI) and occurrence likelihood (OL). The section will then progress to stating the ranking of the risks. The risks will be ranked from most significant, to less significant. The significance of the risk, as stated previously in *Chapter 3*, is determined by the risk score. The risk analysis procedure, with the corresponding RBS can be seen in *Appendix D*.

6.4.1 Risk Quantification by Analyst and Industry Professional

As stated in *Section 6.2*, the quantification will be performed by two participants. The first participant is the analyst, with the second participant being an internally based professional. The following sub-sections will show both quantified data sets. Risk quantification by the analyst requires the individual assessment of each risk. The risks will be listed in accordance with the relative risk criteria, whereupon the occurrence likelihood (OL) and degree of impact (DI) ratings will be provided.

The fuzzy logic risk analysis was performed using the methodology as presented in the study done by Lu *et al.* (2014). *Table 6.5* presents the DI ratings obtained from the analyst and the industry professional. The table also states the difference between the individual ratings of the two data sets. The difference between individual ratings is expressed as the degree of separation on the rating scale. For example, should the analyst give a rating which states the occurrence likelihood of a risk is *Absolutely Unlikely*, and the industry professional states it's *Very Likely*, the difference according to degree of separation is five. The reason for stating the difference between ratings is to emphasise the difference in risk perception. Also, certain risks might be perceived differently due to the professional being based in Australia, whereas the analyst being based in South Africa. As stated previously, the ratings given by the analyst is based on information gained from semi-structured interviews, and referenced academic literature. The degree of separation will be indicated using a colour scheme representation. The colour schemes are presented in *Table 6.4*.

Table 6.4: Degree of Separation for Risk Ratings

Degree of Separation	Colour Representation
None	
1 - 2	
3 - 4	
5 - 6	

The following tables show both ratings obtained from the two participants for each of the individual risks, as well as stating degree of separation between each set of ratings.

Table 6.5: Degree of Impact Rating - Both Participants

Risks	**External Risk – Economic Risk**	Inflation	Changes in relative price/ Price Fluctuation	Foreign exchange rates	Interest rates	Terms of trade	Taxation on imported product	**External Risk – Political and Social Risk**	War in exporting country	Coup d'état	Democratic changes in government	Other political turmoil
Industry Professional		S	A	S	A	US	A		A	US	A	US
Analyst		VUS	US	US	US	S	US		S	US	US	A
Degree of Separation												

Risks	Price controls	Trade Restrictions	Nationalization	Government regulations	Monetary reforms	Changing social concerns	Riots	Terrorist movements	Government relations	**External Risk – Technological Change Risk**	Product innovations	Process innovations
Industry Professional	A	US	US	A	US	US	A	A	US		A	US
Analyst	VUS	VUS	US	S	VS	AUS	A	VS	US		US	US
Degree of Separation												

Risks	Innovation by competitors	**External Risk – Force Majeure Risk**	Hurricanes	Earthquakes	Other natural disasters	Bad weather on open sea	**Internal Local Risk – Sub-Contractor Risk**	Low management competency of sub-contractors	Unavailability of skilled sub-contractors	Lack of coordination between project participants	Sub-contractor lack of adequate equipment or staff	**Internal Local Risk – Safety Risk**
Industry Professional	A		A	A	A	S		S	S	A	A	
Analyst	S		A	A	S	VS		VS	S	S	S	
Degree of Separation												

Risks	Employee safety risk	Labour unrest	**Internal Local Risk – Management Risk**	Unavailability of sufficient professionals and managers	Project size and complexity	Inadequate project management controls	Incorrect balance of resources and expertise	Knowledge inadequacy	**Internal Global Risk – Industry Market Risk**	Changes in the quantity used by others	Shifts in market supply	Availability of product from other sources
Industry Professional	S	A		S	S	S	S	VS		S	S	VS
Analyst	S	S		VS	S	VS	A	VS		S	A	AS
Degree of Separation												

Risks	Scarcity in complimentary products	Rivalry among existing competitors	New entrants in importing industry	**Internal Global Risk – Client Risk**	Design variations by client	Occurrence of disputes	General client generated risk	Client does not allow for adequate time for process	Responsibilities of the client team ill defined	**Internal Global Risk – Contractual Risk**	Product liability uncertainty	Emissions and pollutants liability uncertainty
Industry Professional	A	S	S		A	VS	US	A	US		A	US
Analyst	VS	US	US		S	S	AUS	US	AUS		AUS	VS
Degree of Separation												

Risks	Delay in solving contractual issues	General legal risks	**Internal Global Risk – Environmental Risk**	Ecological constraints	Pollution in harbour during unloading	**Internal Global Risk – Financial Risk**	Inaccurate cost estimation	Corrupt practices	Fraudulent practices	Inadequate project funding	Timing of availability of funds	No budget for contingency measures
Industry Professional	VS	S		US	VS		A	VS	S	A	VS	US
Analyst	S	S		S	VS		S	VS	VS	VS	A	S
Degree of Separation												

Risks	Design errors	Quantity variations	Loss of Cargo	Storage Facilities	**Internal Global Risk – Pre-Contract Risk**	Unproven design solutions adopted	Tendered price	**Internal Global Risk – Product Quality Risk**	Product does not conform to specifications	Viscosity changes of bitumen during transport	**Internal Global Risk – Time Related Risk**	Unloading delay due to machine failure
Industry Professional	US	A	VS	S		VS	US		VS	VS		VS
Analyst	A	A	AS	VS		AS	VS		VS	VS		S
Degree of Separation												

Risks	Unsuitable program planning	Excessive approval procedure in administrative government departments	Attainment of correct documentation and permits	Delay due to labour or equipment productivity	Availability of bitumen specific ports in South Africa	**Internal Global Risk – Trade Compliance Risk**	Incomplete approval and other documents
Industry Professional	A	VS	A	VS	S		S
Analyst	S	A	VS	S	A		A
Degree of Separation							

Table 6.6 shows the OL ratings, as obtained from both participants.

Table 6.6: Occurrence Likelihood Ratings - both Participants

Risks	**External Risk – Economic Risk**	Inflation	Changes in relative price/ Price Fluctuation	Foreign exchange rates	Interest rates	Terms of trade	Taxation on imported product	**External Risk – Political and Social Risk**	War in exporting country	Coup d'état	Democratic changes in government	Other political turmoil
Industry Professional		VL	L	VL	A	UL	A		L	A	L	A
Analyst		VL	VL	L	UL	UL	VUL		L	UL	VUL	L
Degree of Separation												

Risks	Price controls	Trade Restrictions	Nationalization	Government regulations	Monetary reforms	Changing social concerns	Riots	Terrorist movements	Government relations	**External Risk – Technological Change Risk**	Product innovations	Process innovations
Industry Professional	A	UL	UL	A	UL	UL	L	L	UL		A	UL
Analyst	A	A	UL	UL	A	VUL	VL	VL	A		VUL	AUL
Degree of Separation												

Risks	Innovation by competitors	**External Risk – Force Majeure Risk**	Hurricanes	Earthquakes	Other natural disasters	Bad weather on open sea	**Internal Local Risk – Sub-Contractor Risk**	Low management competency of sub-contractors	Unavailability of skilled sub-contractors	Lack of coordination between project participants	Sub-contractor lack of adequate equipment or staff	**Internal Local Risk – Safety Risk**
Industry Professional	A		A	A	A	L		L	L	A	A	
Analyst	VUL		VUL	VUL	L	VL		L	L	VL	VL	
Degree of Separation												

Risks	Employee safety risk	Labour unrest	**Internal Local Risk – Management Risk**	Unavailability of sufficient professionals and managers	Project size and complexity	Inadequate project management controls	Incorrect balance of resources and expertise	Knowledge inadequacy	**Internal Global Risk – Industry Market Risk**	Changes in the quantity used by others	Shifts in market supply	Availability of product from other sources
Industry Professional	L	A		L	L	L	L	L		A	L	L
Analyst	VL	L		VL	VL	VL	A	AL		L	L	L
Degree of Separation												

Risks	Scarcity in complimentary products	Rivalry among existing competitors	New entrants in importing industry	**Internal Global Risk – Client Risk**	Design variations by client	Occurrence of disputes	General client generated risk	Client does not allow for adequate time for process	Responsibilities of the client team ill defined	**Internal Global Risk – Contractual Risk**	Product liability uncertainty	Emissions and pollutants liability uncertainty
Industry Professional	A	VL	L		UL	L	A	A	A		L	UL
Analyst	A	L	VUL		UL	L	L	UL	UL		A	UL
Degree of Separation												

Risks	Delay in solving contractual issues	General legal risks	**Internal Global Risk – Environmental Risk**	Ecological constraints	Pollution in harbour during unloading	**Internal Global Risk – Financial Risk**	Inaccurate cost estimation	Corrupt practices	Fraudulent practices	Inadequate project funding	Timing of availability of funds	No budget for contingency measures
Industry Professional	L	A		UL	L		A	L	A	A	L	UL
Analyst	VL	VL		A	VL		UL	L	L	UL	UL	UL
Degree of Separation												

Risks	Design errors	Quantity variations	Loss of Cargo	Storage Facilities	**Internal Global Risk – Pre-Contract Risk**	Unproven design solutions adopted	Tendered price	**Internal Global Risk – Product Quality Risk**	Product does not conform to specifications	Viscosity changes of bitumen during transport	**Internal Global Risk – Time Related Risk**	Unloading delay due to machine failure
Industry Professional	L	L	L	A		L	L		VL	L		VL
Analyst	UL	A	A	VL		UL	VL		VL	AL		L
Degree of Separation												

Risks	Unsuitable program planning	Excessive approval procedure in administrative government departments	Attainment of correct documentation and permits	Delay due to labour or equipment productivity	Availability of bitumen specific ports in South Africa	**Internal Global Risk – Trade Compliance Risk**	Incomplete approval and other documents
Industry Professional	A	L	L	VL	L		A
Analyst	UL	VL	VL	L	AL		L
Degree of Separation							

The risk ratings for both the DI and OL, as provided by both participants are fairly similar. 72.67% of the risk ratings are similar. In total, for both the degree of impact and occurrence likelihood, 22.67% of risk ratings are within a one-to-two degree of separation. 4.67% of the risks of the risks are within a three-to-four degree of separation, with 0% of risk ratings falling within the six-to-seven degree of separation. The risk ratings which fall within a three to four degree of separation is due to two reasons namely, (1) the analyst has no practical experience with bitumen importation, and (2) the industry professional is based in Australia and managed imports to China. However, the risk ratings are presented to provide an indication as to the most significant risks when importing bitumen. This information can be used by firms which are inexperienced in the field of importing bitumen to South Africa, as it provides an indication as to where more research and expertise are needed.

6.4.2 Fuzzy Logic Risk Analysis and Result Discussion

The following section shows the risk rankings, as well as stating and discussing the top 10 most significant risks. The fuzzy logic implementation was done on *Microsoft Excel* can be seen in

Appendix D. As previously stated, the fuzzy logic risk assessment methodology is implemented as was done in the study of Lu *et al.* (2014). *Table 6.7* shows the risk rankings.

Table 6.7: Risk Ranking after Fuzzy Logic Risk Assessment

Risks	**External Risk – Economic Risk**	Inflation	Changes in relative price/ Price Fluctuation	Foreign exchange rates	Interest rates	Terms of trade	Taxation on imported product	**External Risk – Political and Social Risk**	War in exporting country	Coup d'état	Democratic changes in government	Other political turmoil
Risk Rank		36	43	33	57	60	68		30	66	59	46
Risks	Price controls	Trade Restrictions	Nationalization	Government regulations	Monetary reforms	Changing social concerns	Riots	Terrorist movements	Government relations	**External Risk – Technological Change Risk**	Product innovations	Process innovations
Risk Rank	62	72	71	46	50	75	35	14	66		68	74
Risks	Innovation by competitors	**External Risk – Force Majeure Risk**	Hurricanes	Earthquakes	Other natural disasters	Bad weather on open sea	**Internal Local Risk – Sub-Contractor Risk**	Low management competency of sub-contractors	Unavailability of skilled sub-contractors	Lack of coordination between project participants	Sub-contractor lack of adequate equipment or staff	**Internal Local Risk – Safety Risk**
Risk Rank	55		62	62	37	6		18	25	28	28	
Risks	Employee safety risk	Labour unrest	**Internal Local Risk – Management Risk**	Unavailability of sufficient professionals and managers	Project size and complexity	Inadequate project management controls	Incorrect balance of resources and expertise	Knowledge inadequacy	**Internal Global Risk – Industry Market Risk**	Changes in the quantity used by others	Shifts in market supply	Availability of product from other sources
Risk Rank	18	37		6	18	6	37	2		30	30	5

Risks	Risk Rank	Risks	Risk Rank	Risks	Risk Rank	Risks	Risk Rank
Unsuitable program planning	46	Design errors	51	Delay in solving contractual issues	6	Scarcity in complimentary products	42
Excessive approval procedure in administrative government departments	14	Quantity variations	44	General legal risks	24	Rivalry among existing competitors	33
Attainment of correct documentation and permits	14	Loss of Cargo	13	**Internal Global Risk – Environmental Risk**		New entrants in importing industry	53
Delay due to labour or equipment productivity	6	Storage Facilities	14	Ecological constraints	51	**Internal Global Risk – Client Risk**	
Availability of bitumen specific ports in South Africa	22	**Internal Global Risk – Pre-Contract Risk**		Pollution in harbour during unloading	4	Design variations by client	54
Internal Global Risk – Trade Compliance Risk		Unproven design solutions adopted	23	**Internal Global Risk – Financial Risk**		Occurrence of disputes	18
Incomplete approval and other documents	37	Tendered price	27	Inaccurate cost estimation	46	General client generated risk	70
		Internal Global Risk – Product Quality Risk		Corrupt practices	12	Client does not allow for adequate time for process	57
		Product does not conform to specifications	1	Fraudulent practices	26	Responsibilities of the client team ill defined	73
		Viscosity changes of bitumen during transport	2	Inadequate project funding	45	**Internal Global Risk – Contractual Risk**	
		Internal Global Risk – Time Related Risk		Timing of availability of funds	41	Product liability uncertainty	65
		Unloading delay due to machine failure	6	No budget for contingency measures	60	Emissions and pollutants liability uncertainty	56

The top 10 most significant risks will be discussed and verified. The verification of the most significant risks is based on information gained from the semi-structured interviews. Each of the individual risks will be shortly discussed.

Product does not conform to specifications

During the semi-structured interviews with industry professionals, this risk was highlighted to be a large concern. Mr. Robinson's company identified the risk being the most significant when researching the feasibility of importing bitumen. Should the product not conform to specification it will be inadequate for use on site. Furthermore, the financial implications associated with a loss of this magnitude can cripple, or in worst case scenario, bankrupt a construction organisation. The non-conformance of the bitumen product will also require the procurement of additional product for the project at hand.

The professionals from SANRAL stated that as a client, their largest concern is the conformation of the product with bitumen specifications. This was emphasised during the interviews. SANRAL stated that should the product not conform, the risk and consequences associated with the non-conformance would be carried by the contractor. Furthermore, Mr. Schafer and Mr. Louw, being experienced in the field of bitumen importation, stated that the conformation of the product was the largest concern when importing bitumen from a new supplier.

The SABITA import guide stated that quality control is one of the most important aspects of bitumen importation. The risk is partially mitigated when using a shipping agent, however viscosity changes do occur. The viscosity changes cannot be regulated, nor can they be controlled. Thus, the risk can be concluded to be the most significant risk when importing bitumen.

Viscosity changes of bitumen during transport

The viscosity changes of bitumen during transport was highlighted by Mr. Louw and Mr. Schafer as being a large concern. The viscosity changes are unpredictable, uncontrollable and inevitable, only being mitigated by the shipping vessel being used. Modern shipping vessels have improved heating and monitoring systems, giving ship operators the ability to control the heat within the storage tanks optimally. When using older shipping vessels, bitumen should be tested at the time of departure, and upon arrival. However, for both types of vessels the viscosity changes will be unpredictable. The result of drastic viscosity changes can lead to bitumen being out of specification. One mitigation strategy to consider, is importing a bitumen with a penetration result which lies close to the centre of the penetration grade specification. Should viscosity changes occur, the results shown in *Appendix F*, shows that the average viscosity change, either harder or softer, is 4.58. This means that the bitumen penetration result will still be within the penetration specifications.

Knowledge inadequacy

When interviewing Mr. Schafer, emphasis was placed on the managerial component of importing bitumen. It was stated by Mr. Schafer that inadequate experience and knowledge regarding the importation process of bitumen can cause time and monetary difficulties early in the process. Knowledge inadequacy refers to the lack of experience and knowledge of either the importing company, or the managerial staff associated with the process. A large portion of the intellectual property regarding the risks associated with bitumen importation is centred on managerial procedures. This can be seen as an indication of the complexity level for such a managerial exercise. Mitigating this risk requires organisations to invest in experienced personnel, or outsourced professionals.

Pollution in harbour during unloading

The SABITA import guide placed emphasis on the harbour rules and regulations. Mr. Louw, Mr. Schafer and Mr. Fourie stated that harbour pollution should be avoided at all times. All three professionals stated that large fines can occur should product be spilled. The liability of the pollution is based on the shipping documents, being the party responsible for the unloading of bitumen. COLAS constructed unloading gantries, ensuring that bitumen product will not be spilled into the harbour.

Availability of product from other sources

Should the exporting refinery experience an unplanned shutdown, it is the responsibility of the importer to locate a different source. The availability of bituminous product from the new source is impacted by various variables. Some of the variables, as identified by Mr. Schafer and Mr. Fourie, are the product quality, the location of the refinery (being in the same region as the previous refinery) and the exporting capacity of the refinery. The result of this risk could lead to schedule implications, which will result in financial losses. Mitigating this risk requires importers to research additional trustworthy, and accredited exporters. Should the current exporter experience bitumen shortages, the importer will have additional supplies, limiting the potential for time delays.

Unloading delay due to machine failure

The risk was emphasised by COLAS after importing bitumen in 2013. According to the COLAS website, the unloading of the imported bitumen would have been performed quicker, however due to machine failure and limited resources, the process was delayed. Such a delay results in additional costs to the party responsible for the unloading of the product. This being said, machine failure is an uncontrollable event. The risk can be mitigated by means of (1) extensive machine-checks and testing before unloading, (2) acceptance of the risk, or (3) using sub-contractors for the unloading process thus shifting the risk responsibility.

Unavailability of sufficient professionals and managers

As previously stated, Mr. Schafer placed great emphasis on the managerial component associated with the import of bitumen. A lack in professionals and managers experienced in bitumen importation will lead to delays and financial implications. Potential South African importers are faced with the challenge of finding experienced personnel, as the process of importing bitumen is relatively new. This creates a large problem for potential South Africa importers, as the consequences associated with the risk of failure is very high. Failure of any sort will lead to large financial losses, resulting in potential importers only having to succeed.

Inadequate project management controls

As previously stated, Mr. Schafer placed great emphasis on the managerial component associated with the import of bitumen. The management component for the bitumen import process is regarded as the most complex and risk filled.

Delay in solving contractual issues

The importation of bitumen requires the cooperation of different parties. As stated in *Chapter 4*, there are contractual agreements between the parties involved, when importing bitumen. This ensures accountability and the fair distribution of risk. However, the fair distribution of risk is not always possible, resulting in contractual issues. Mr. Schafer, Mr Fourie and SANRAL highlighted the importance of well-defined contractual agreements. The settlement of the agreements, or the breaching thereof, can result in legal issues, which as a result will have schedule and monetary implications.

Bad weather on open sea

This risk was identified by Mr. Schafer and Mr. Fourie as being highly probable, and having a large financial impact in terms of schedule delays.

6.5 Conclusion

The chapter aimed at reporting on a sub-system of the bitumen import system, being the risk management system. The traditional risk analysis method requires the input of crisp data, which is not vague, and cannot be in terms of linguistic variables. When analysing the bitumen import system, analyst will be faced with vague data, as not a lot of risk knowledge exist due to organisations not having attempted international procurement of bitumen. A different, more flexible risk management system should thus be used to accurately quantify the identified risks. These types of management systems are known as Multi-Criteria Decision Models (MCDM), and are directly applicable to real world risk management. The MCDM best suited to deal with vague or fuzzy data, is a MCDM model based on fuzzy logic. The fuzzy logic methodology allows for vague data to be used as input data for risk management scenario. The vague input data is based on linguistic variables, with each linguistic variable defining a range of possible values. It allows for industry professionals to base their judgements on professional knowledge, instead of personal experience.

The fuzzy logic risk analysis process was defined and implemented. The top 10 most significant risks were identified from the risk assessment output. The top 10 most significant risks, from most significant to least significant, are (1) Product does not conform to specifications, (2) Viscosity changes of bitumen during transport, (3) Knowledge inadequacy, (4) Pollution in harbour during unloading, (5) Availability of product from other sources, (6) Unloading delay due to machine failure, (7) Unavailability of sufficient professionals and managers, (8) Inadequate project management controls, (9) Delay in solving contractual issues, and (10) Bad weather on open sea. The most significant risks is verified using information gained from interviewing industry professionals. It can be concluded that the risk ratings provided by the analyst, in conjunction with the ratings obtained from Mr. Fourie, provide a sufficient indication of the risk structure for organisations attempting to import bitumen. The identified risks and their associated ratings can be used as a guideline for future importers, providing information as to where resources should be allocated. It also gives an indication as to areas of the risk environment which require additional research, and more comprehensive quantification study.

CHAPTER 7

CONCLUSION

The aim of this chapter is to summarise the research report, also stating how each of the chapters contributed to the solving of the research problem. When starting the research project, it was found that limited literature on the logistic planning and management, as well as risks involved in the importation process was available. With this as background the problem statement for this study was formulated as: *What are the procedures and risks involved when importing bitumen into South Africa?* The primary objective of the study was determined to be the identification of the risks involved when importing bitumen into South Africa.

Given that the focus of the study was directed at the identification of the risks involved for the import of bitumen, a research design and methodology could be developed. *Chapter 2* aimed at giving a structured guideline as to how the study will be performed in terms of research methods used, primary and secondary objectives, research instruments to be used, scope and limitations of the study, and ethical considerations to be taken into account. The type of research to be implemented was applied research with qualitative sub-components.

The literature study that was performed in *Chapter 3*, showed that the South African bitumen industry is self-sustaining, should no unplanned shutdowns occur. It was found that the road construction industry requires between 20- and 30 million litres of bitumen annually, which is much less than the quantity produced by South African refineries, being between 430- and 450 million litres of bitumen. However, large quantities of the produced bitumen is exported to various international destinations. South Africa ranked in the top 15 bitumen exporting countries. This as a result indicated that the quantity of bitumen allocated to the South African road construction industry covers the demand, even in times of planned shutdowns, but fails to do so when unplanned shutdowns occur. It was thus found that in order to fully analyse the risk nature of the industry, a global risk management perspective had to be implemented. When researching global risk management, a lot of emphasis was placed on the risk identification involved. Various studies concluded that risk identification plays one of the most import roles, acting as a foundation for the management process. Chapman (1998) identified various techniques for adequate risk identification. The techniques which were best suited for the study is *Identification by Risk Analyst* and *One-to-one interviews*. As stated, the traditional risk management was defined. In addition to this, the use of multi-criteria decision models (MCDM) for risk analysis were described. This entailed stating different models as well as defining the selection process for a MCDM to be used for the study at hand. Due to the data being classified as vague, it was deemed best to use a fuzzy logic methodology. The fuzzy logic risk analysis procedure was defined in *Chapter 6*, where it was implemented for the risk analysis.

The bitumen import systems analysis was performed in *Chapter 4*. The chapter aimed at analysing bitumen importation by means of systems theory. The system itself was seen as a gate-to-gate system, only looking at the production phase of the bitumen, which in this case is the importation thereof. The system was divided into its various components, being physical, organisational and managerial. The analysis study revealed that bitumen importation is best done using shipping vessels as larger quantities can be imported in a single session. The drawback to this was however revealed through interviews, as the topic of storage facilities was stressed. For smaller amounts, bitutainers or bitumen bags can be used, with steel drums not being recommended as losses are experienced during extraction of the product. However, these methods also require large storage space.

The organisation components discussed the various parties involved, being the client, contractor, sub-contractor, shipping company and 3de party representatives (shipping agents). From the interviews, it was stated that one of the largest shipping agent companies is SGS S.A. The shipping agent organisation is responsible for testing at the refinery location before the product is shipped. Furthermore, the managerial component of the bitumen import system was divided into various elements namely financial-, logistical-, quality-, health-, safety- and environmental management. For the financial management element, the importance of a LC was stressed a lot, and deemed to be essential to the operation. The logistical element was defined in terms of the different documentary requirements associated with the bitumen import system, as well as stating the import procedure to be followed. Should an organisation consider such an operation, the United Nations and SGS have developed a document specifically defining the documentary risk in commodity trade. A document checklist can be found at the end of this guideline document (SGS S.A., 1998:129). In addition it should be stated that the SABITA import guide was referenced for the quality assurance of the bitumen, in which the different standards were stated. The SABITA import guide was also referenced for the ports cargo handling and port safety operations.

Chapter 5 was aimed at the identification of risks involved for the import process of bitumen. The chapter was compiled using data obtained from academic literature, as well as interviews with industry professionals. The RBS is a hierarchal structure, consisting of risk criteria and furthermore identified risks. For the identification of the various risk criteria, 10 sources were analysed. The first level of the RBS consisted of external and internal risk, where upon internal risk was further sub-divided in to Global and Local risks. From this point the risk identification could commence. The risk identification, for each of the risk criteria, was done using academic literature as well as personal interviews. The process was done in conjunction with the guidelines stated in *Chapter 3*. In total, 75 risks were identified and described.

Chapter 6 was aimed at reporting on a sub-system of the bitumen import system, being the risk management system. When analysing the bitumen import system, it was found that the analyst will be faced with vague data, as not a lot of risk knowledge exist, due to organisations not having attempted international procurement of bitumen. The best suited MCDM to deal with vague or fuzzy data, is based on a fuzzy logic methodology. The fuzzy logic methodology allows for vague data to be used as input data for risk management scenario. It allows for industry professionals to base their judgements on professional knowledge, instead of personal experience. Upon completion of the fuzzy logic risk assessment, the top 10 most significant risks were identified. The top 10 most significant risks, from most significant to least significant, are (1) Product does not conform to specifications, (2) Viscosity changes of bitumen during transport, (3) Knowledge inadequacy, (4) Pollution in harbour during unloading, (5) Availability of product from other sources, (6) Unloading delay due to machine failure, (7) Unavailability of sufficient professionals and managers, (8) Inadequate project management controls, (9) Delay in solving contractual issues, and (10) Bad weather on open sea. The most significant risks were verified using information gained from interviewing industry professionals. It was concluded that the risk ratings provided by the analyst, in conjunction with the ratings obtained from Mr. Fourie, provided a sufficient indication of the risk structure for organisations attempting to import bitumen.

This research report was done to assist organisations with the bitumen import system, in terms of documentary requirements, procedural outlines and a preliminary risk database. The research can hopefully be used in the future, should bitumen importation become a reality once more. It should however be stated that through knowledge gained from academic literature, and interviews, that importing bitumen is a complex process. The complexity associated with importing bitumen stems from the extensive logistical management, which if not done correctly could have large financial consequences.

CHAPTER 8

RECOMMENDATIONS FOR FURTHER STUDY

8.1 Introduction

The following section will state recommendations for further study. The topics for further study were identified whilst performing the research study. Each of the recommended topics will be stated with a short description of each.

8.2 Quantitative Risk Assessment for the Import of Bitumen

The current research study was aimed at identifying the procedures, logistical requirements and risks associated with the import of bitumen into South Africa. The quantification of the risks were seen as secondary research objective. As such, for further study a predominantly qualitative research study could be performed. This would require an analyst taking the same identified risks, adding more, and quantifying them in terms of occurrence likelihood and degree of impact using more participants. Using more participants would give a better indication as to how importers perceive certain risks. If intellectual property still exist regarding the importation of bitumen into South African, the choice to use Australian or Chinese professionals should be made. The reason for this is that both Australia and China import large quantities of bitumen. The quantitative risk assessment could also potentially incorporate the way in which the South African construction companies perceive different risks.

8.3 Cost Comparison between Locally Sourced Bitumen and Imported Bitumen

The study at hand did not compare imported bitumen to locally sourced bitumen, instead the study focussed on importation individually. For further study, a cost comparison can be performed between locally sourced bitumen and imported bitumen. The cost analysis should indicate the monetary difference between the two procurement strategies. However, when performing the study a reference city should be selected to which there will be imported, and where there will be locally sourced. This is due to large transportation costs when transporting bitumen from Durban, or Sasolburg, to Cape Town. The study should include a comparison between transporting bitumen between two cities in South African, and importing bitumen from an international destination. The cost comparison should also include the costs associated with shipping bitumen from different countries, for example some exporting countries being further away from South Africa. Import duty should also be taken into account.

8.4 The Development of a Bitumen Specific Port Terminal

As stated in the research study, South Africa does not have a bitumen specific port terminal. Research should be performed to determine the financial implications of constructing a bitumen specific port terminal. The terminal should be capable of have specific bitumen extracting pumps, as well as being able to pump the bitumen to storage facilities located close to the harbour. This type of unloading system is seen in countries such as Australia and China.

8.5 Which Internally Sourced Bitumen is best Suited for use in South Africa

Different bitumen sourced from different international refineries, all differ in quality, as well as being different in terms of suitability for use in South Africa. For further study, the best suited internally sourced bitumen for South Africa can be determined. The bitumen, having to be within South African bitumen specifications, should also be compatible in terms of climatic conditions.

8.6 Comparison between Different Risk Analysis Procedures

For the study at hand, a fuzzy logic based MCDM was implemented. However, as stated in *Chapter 3*, various MCDM exist, as well as the traditional risk analysis procedure. For further study, a comparison between various risk analysis procedures can be performed. Using the fuzzy logic output as a baseline result, to which the traditional method and various other MCDM methods can be compared.

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APPENDIX A

INTERVIEWS CONDUCTED

Adrian Robinson

The questions asked were based on the identification of risk for the importation of bitumen into South Africa. Summaries of the answers are as follows:

Question 1: Has their company considered importing bitumen?

The company has researched the possibility of importing bitumen. This was done in 2012 during the bitumen shortages.

Question 2: What were the largest concerns regarding the import of bitumen?

The following are the most significant concerns:

- Quality assurance of the product during the time of transport;
- Storage facilities for the imported bitumen, as large quantities will be imported at once;
- The tender process was also considered to be a concern. The problem is that the awarding of the tender takes time, resulting in the company having to import bitumen before the tender is awarded. The risk of not getting the tender thus arises;
- Transportation of the bitumen from port to possible location site is an expensive procedure;
- The import of bitumen requires large upfront payments;
- The environmental and logistics management associated with a project of this size requires large amount of resources;
- Modification of bitumen plays a large role in the road construction industry. When importing bitumen, facilities have to be in place for the modification procedures;
- The modification of bitumen needs specific materials, this material must also be imported and thus creates additional costs;
- Importation with drums, bitumen bags and bitutainers are an option, but also creates problems for storage and also additional transportation costs, and
- The feasibility of such a project, in terms of management practices and financial obligations, is under question as bitumen does not play a big role in terms of cost in a construction project.

Danie Erasmus and Gerhard Fourie

The questions asked were based on the contractual clauses and obligations surrounding the importation of bitumen into South Africa. Summaries of the answers are as follows:

Question 1: Which construction contract is mostly used by SANRAL?

SANRAL uses FIDIC construction contracts, and has done so for the past 15 years.

Question 2: Are there additional clauses inserted for events such as the import of bitumen?

No additional clauses are placed in the construction contracts for the importation of bitumen. The contracts however state that the sourcing of bitumen is a risk carried by the contractor. Should a shortage develop in the Western Cape, the sourcing of new product is the responsibility of the contractor. Whether the procurement location is locally or internationally, the bitumen used just have to comply with South African bitumen specifications.

Question 3: What was the procedure for 2012 when bitumen was imported?

The import of bitumen in 2012 was due to large amount of unfinished projects, and the commencement of new projects. For the time period where a bitumen shortage was experienced, SANRAL took initiative and adjusted for the additional costs associated with the import of bitumen. However, it was stated by SANRAL that the risk will be carried by the contractor and not the client. SANRAL was only concerned with the bitumen as it arrived on site, being that the bitumen had to be within the specifications. Additional guidelines, for the use and testing of imported bitumen, were produced and implemented by SABITA.

Question 4: Concerns surrounding planned and unplanned shutdowns of refineries?

The construction industry is informed in terms of the shutdown schedules of refineries. However, unplanned shutdowns do occur, creating problems for the construction industry. Even with planned shutdowns, South African refineries are more than capable of supplying the demand of the South African construction industry. The demand of South Africa is between 430- to 450 million litres of bitumen annually. This being said, bitumen is less than one percent of the output of a refinery. If unplanned shutdowns do occur, in conjunction with planned shutdowns, it usually ends up in bitumen shortages.

Question 5: Additional problems surrounding the process of bitumen importation?

The following are concerns from a client's perspective on the import of bitumen

- The storage of bitumen is problem, should large quantities be imported.
- The cost control of locally sourced and imported bitumen. The problem arises when both sources of bitumen are mixed together. The client has no control over the bitumen being used on site, and thus no control of the costs associated.

Johan Fourie

Communication between Mr. Fourie were done via email, as Mr. Fourie is currently living in Australia. The questions asked were based on the risk identification and procedural obligations surrounding the international trade of bitumen. Mr. Fourie was previously involved with importing bitumen into China. Summaries of the answers are as follows:

Question 1: What are the risks involved when importing bitumen?

The risks which were identified by Mr. Fourie are the following:

- Relationship between buyer and seller
  - Buyer and seller have to be willing to avoid legal disputes.

  - Buyer have to do a due diligence on the financial capability of the seller.
  - Contract should be directly between seller and buyer.
- Requirements regarding the specification of bitumen in importing country
  - Seller must be fully aware of the climactic conditions in which the buyer aims to use bitumen.
  - When importing to China, wax percentage of bitumen plays a large role
- Supplier's country of origin.
  - Best bitumen originates from Iran.
  - Difficult to import from Iran due to sanctions.
- Shipping of bitumen
  - Importation method plays a large role.
  - Importation of bitumen using drums is problematic.
  - Overheating of bitumen should be avoided.

Question 2: What are documentation and procedures associated with Bitumen Importation?

The procedural obligations and documentation requirements identified by Mr. Fourie are the following:

- Buyer should request Full Corporate Offer (FCO) from seller, which will stipulate most of the trading terms and specifications.
- The FCO is signed and in return the buyer is subject to an inspection of the refinery, loading port and table top meeting with the seller to finalise the terms and conditions of the contract.
- Payment terms are extremely important, with the best terms to negotiate being the shipping documentation.
- The buyer is responsible for Free on Board (FOB) costs, which includes insurance to discharge port, whereupon the buyer is responsible for cost of clearance.
- One of the most import conditions of contract is the appointment of a shipping agent.
- One of the best organisations to use as shipping agents is SGS S.A. They specialise in verification of the quantity, weight and quality of traded goods, as well as testing the product quality and performance against various health, safety and regulatory standards. They make sure that the product, systems or services meet the requirements of standards set by governments.
- Very important aspect needed for the importation of bitumen, which protects the buyer and seller, is an unconditional, irrevocable letter of credit (LC).
- Payments are normally made by the bank which authorised the LC.
- Payments are made using Telegraphic Transfer (TT) from the bank to the seller, with the payment normally taking up to three weeks.
- The bank cannot authorise the payment until shipping documentation and terms of contract is received.

Question 3: What shipping documentation are needed?

- Original Bill of Lading
- Certificate of Origin
- Commercial Invoice
- SGS Report Certificate
- Packing List

Kobus Louw

The questions asked were based on the product (bitumen) risks during the import process. Summaries of the answers are as follows:

Question 1: What were the main concerns for COLAS surrounding the import of bitumen?

The following were the largest concerns for COLAS:

- Storage facility for large amounts of bitumen was the largest concern;
- The aging of the bitumen, being viscosity changes, during the transportation component of the bitumen importation system;
- The compatibility of the bitumen, in terms of modification and South African climactic conditions;
- Import duty played a role when importing from certain countries;
- The logistics management associated with the project was a big concern, and
- The financial obligations associated with the import process.

Question 2: Solutions for import associated concerns?

The shipment of bitumen was a joint venture between COLAS, Much Asphalt and Raubex. The transportation of the bitumen was also not such a big problem as the COLAS owns a bitumen shipping vessel named the TASCO 1. COLAS did however get SGS to perform bitumen specification testing at the location of the exporting refinery. Furthermore, additional gantry unloading systems had to be constructed for the unloading of bitumen. The unloading process was done using bitumen specific road tankers and bitutainers. The product was stored in bitutainers, storage tanks at the COLAS batch plant, and storage facilities hired by COLAS, located near the port.

Mitch Schafer

Communication between Mr. Schafer were done via email. The questions asked were based on the procedural obligations and logistics management surrounding the importation of bitumen into South Africa. Mr. Schafer was asked to verify the documentation requirements, import procedure and risk identification, also stating if more information had to be added. The information gained from Mr. Schafer response was that intellectual property exist surrounding the risk management procedure of bitumen importation. Mr. Schafer also verified all the risk as correct and accurate. Furthermore, Mr. Schafer stated that the largest risks are associated with the logistics management procedures of bitumen.

APPENDIX B

FUZZY LOGIC IMPLEMENTATION EXAMPLE

Introduction

The fuzzy logic implementation methodology was described in *Section 6.3*. This MCDM was selected based on the principle of vague data. Users of this model is given the freedom of using data that is not crisp, but imprecise, as the fuzzy logic risk analysis technique uses linguistic terms as input. The linguistic terms are accompanied by a membership function, which encompasses a range of values for a specific linguistic term, rather than one crisp value. This being said, the fuzzy logic risk assessment methodology recommended for an import risk analysis is based on a study done by Lu *et al.* (2013) on the reconstruction of railway systems in Taiwan. The selection of this methodology was based on the similarities of both studies. The highest priority similarities are vague input data and the nature of the project being a new venture for the construction industry. As such, the rest of the section consists of a risk problem description and the implementation of the fuzzy logic methodology. The implementation procedure aims to present a risk ranking example in an understandable manner (Lu, Yu & Chang, 2014).

Problem Description

The problem to be solved was selected from the study performed by Lu *et al.* (2013). As stated above, the study by Lu *et al.* (2013), was a fuzzy based risk assessment approach on railway reconstruction in Taiwan. The risk breakdown structure used for the assessment consisted of seven risk criteria categories, with risks being identified for each of the risk criteria. In total 31 risks were identified. The risk breakdown structure, as gained from the article of Lu *et al.* (2013), is as follows:

F_1: Financial and Economic Risk

- F_{11}: Interest rate of loan increasing
- F_{12}: Funds unavailability of contractor
- F_{13}: Material price fluctuation
- F_{14}: Wages and salaries increasing

F_2: Contractual and Legal Risk

- F_{21}: Delay in solving contractual issues of official matter
- F_{22}: Delay in solving disputes
- F_{23}: Delay payment on contract and extra
- F_{24}: Delay in change order negotiation

F_3: Subcontracting-Related Risk

- F_{31}: Subcontracting lack of adequate experiences
- F_{32}: Subcontracting lack of adequate number of workers

- F_{33}: Poor coordination with subcontractors
- F_{34}: Poor management of subcontractors

F_4: Operational and Safety Risk

- F_{41}: Incompatibility with original railway operations
- F_{42}: Limitations of construction sites
- F_{43}: Difficulties in relocation of original pipelines
- F_{44}: Incomplete construction equipment
- F_{45}: imperfect construction quality
- F_{46}: Accidents and hazards

F_5: Political and Social Risk

- F_{51}: Political decisions or policies variations
- F_{52}: More requirement in pollution regulations
- F_{53}: Occupational safety and health regulations change
- F_{54}: Resident's protest and disturbances

F_6: Design Risk

- F_{61}: Inadequate construction methods
- F_{62}: Defective design documents
- F_{63}: Conflict of construction interfaces
- F_{64}: Inadequate construction specifications
- F_{65}: Questionable construction site investigation

F_7: Force Majeure Risk

- F_{71}: Typhoon
- F_{72}: Earthquake
- F_{73}: Fire Accident
- F_{74}: Poor Geological Conditions

The risks criteria was determined by means of literature. Eighteen sources were thoroughly assessed from which the risk criteria was determined. The risks associated with each of the risk criteria was identified by means of literature, and through experience in the railway reconstruction industry of Taiwan. Upon completion of the risk breakdown structure, 23 industry professionals were asked to quantify the risks in terms of occurrence likelihood and degree of impact. The linguistic terms, as previously mentioned, was used for the quantification of these two variables, for each of the individual risks. The quantification procedure and related use in the assessment model is explained the following section.

Implementation

The complete quantification of both occurrence likelihood and degree of impact can be found in the article as published by Lu *et al.* (2013). The fuzzy logic procedure was performed in a systematic manner, with the degree of impact input data and occurrence likelihood input data, being handled separately. The implementation procedure example will be performed in a step wise manner in order to explain each of the calculation steps adequately. The calculations will follow the methodology as defined in *Section 5.5.3*.

Step 1: Identify a Weighing and Scoring Team

As stated previously, 23 experts comprised of 18 males and five females were used. Seven of the 23 had experience between 10 to 15 years, eleven had experience of 15 to 20 years and five of the experts had experience of above 20 years.

Step 2: Fuzzy Number Selection

The process of selecting the appropriate fuzzy numbers for the problem at hand is described in *Section 6.3.2*.

Step 3: Definition of Linguistic Variables

Defining the linguistic variables was defined in *Section 6.3.3*. *Table 5.6* and *Table 5.7* displays the linguistic variables for degree of impact and occurrence likelihood accordingly.

Step 4: Determining the Risk Factor's Degree the Impact TFN values

The Trapezoidal Fuzzy Number listing in matrix format is theoretically explained in *Section 6.3.4*.

Step 5: Determining the Risk Factor's Occurrence Likelihood TFN values

The Trapezoidal Fuzzy Number listing in matrix format is theoretically explained in *Section 6.3.5*.

Step 6: Determining the Overall Ranking of the Risks

The risks were evaluated using the linguistic variables as stated. The linguistic ratings for *Criteria* F_1 of degree of impact is shown in *Table B.1* and *Table B.2*. The full table is not displayed as the purpose of this section is to display calculations.

Table B.1: The evaluation results of degree of impact for risk factors E_1 - E_{11} (Lu, Yu & Chang, 2014)

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8	E_9	E_{10}	E_{11}
F_{11}	S	S	VS	VS	A	A	A	U	S	A	U
F_{12}	A	AS	AS	AS	VS	A	VS	A	VS	S	S
F_{13}	VS	VS	VS	VS	S	VS	S	S	AS	S	VS
F_{14}	VS	VS	VS	A	A	S	A	A	S	U	A

Table B.2: The evaluation results of degree of impact for risk factors E_{12} - E_{23} (Lu, Yu & Chang, 2014)

	E_{12}	E_{13}	E_{14}	E_{15}	E_{16}	E_{17}	E_{18}	E_{19}	E_{20}	E_{21}	E_{22}	E_{23}
F_{11}	A	A	S	A	S	A	S	S	A	A	S	S
F_{12}	VS	S	AS	A	S	U	S	VS	AS	S	U	VS

F_{13}	VS	VS	VS	S	VS	VS	S	VS	S	VS	S	S
F_{14}	VS	U	A	S	A	A	A	S	A	U	A	S

In the tables above, F_{11} denotes risk one of risk category one, whereas E_1 denotes that it is professional number one. As such, after the evaluation process, the linguistic variables are replaced with their corresponding fuzzy numbers. It is then that *Equation 11* is implemented to calculate a synthesized fuzzy number that incorporates the ratings of all the evaluators. The following calculation, represented by *Equation 15*, represents how the formula is implemented in order to calculate the synthesized TFN value for risk F_{11}.

$$Synthesized\ TFN\ for\ F_{11} = \frac{1}{23}\left[E_1^{F11} + E_2^{F11} + \cdots + E_{23}^{F11}\right] \tag{15}$$

Upon completion of this process for each of F_{11}, F_{12}, F_{13} and F_{14}, the following values are obtained:

Table B.3: Synthesized value calculation (Lu, Yu & Chang, 2014)

	Impact TFN's
F_1	
F_{11}	(0.46, 0.56, 0.60, 0.70)
F_{12}	(0.57, 0.67, 0.73, 0.81)
F_{13}	(0.63, 0.73, 0.77, 0.87)
F_{14}	(0.45, 0.55, 0.58, 0.68)

The best non-fuzzy performance (BNP) value can be calculated using *Equation 12*. As defined in *Section 6.3.6.2*, the BNP values were obtained using the de-fuzzification principal known as the centroid method. *Table B.4* presents the four BNP values for each of the individual risks and a representation of how *Equation 12* is implemented.

Table B.4: Calculating the BNP values for the risk (Lu, Yu & Chang, 2014)

	Impact BNP's	Example Calculation
F_1		
F_{11}	0.578	$\frac{0.6^2 + 0.7^2 + 0.6 \cdot 0.7 - 0.46^2 - 0.56^2 - 0.46 \cdot 0.56}{3(0.6 + 0.7 - 0.46 - 0.56)}$
F_{12}	0.696	
F_{13}	0.746	
F_{14}	0.565	

The following table was taken from the article published by Lu *et al.* (2013). The local weight for each risk is calculated by dividing each individual risk's BNP value by the sum of all the BNP values for the specific risk category. Furthermore, the local ranking is the ranking of each individual BNP value within the risk category. The global weight of the risks is calculated by dividing each individual risk's BNP value by the sum of all the BNP values over all the categories. From this the global ranking is achieved. It has to be noted that *Table B.5* only displays the global risk ranking for the degree of impact.

Table B.5: The degree of impact and its ranking for each risk factor (Lu, Yu & Chang, 2014)

	Impact TFNs	Impact BNPs	Local weights	Local ranking	Global weights	Global ranking
F_1						
F_{11}	(0.46, 0.56, 0.60, 0.70)	0.578	0.224	3	0.030	27
F_{12}	(0.57, 0.67, 0.73, 0.81)	0.696	0.269	2	0.036	3
F_{13}	(0.63, 0.73, 0.77, 0.87)	0.746	0.289	1	0.039	1
F_{14}	(0.45, 0.55, 0.58, 0.68)	0.565	0.219	4	0.029	29
F_2						
F_{21}	(0.48, 0.58, 0.63, 0.73)	0.604	0.252	3	0.031	19
F_{22}	(0.49, 0.59, 0.65, 0.74)	0.616	0.257	2	0.032	17
F_{23}	(0.43, 0.53, 0.58, 0.68)	0.552	0.230	4	0.029	30
F_{24}	(0.50, 0.60, 0.66, 0.75)	0.629	0.262	1	0.033	13
F_3						
F_{31}	(0.53, 0.63, 0.68, 0.77)	0.653	0.260	1	0.034	8
F_{32}	(0.50, 0.60, 0.65, 0.75)	0.624	0.249	3	0.032	16
F_{33}	(0.48, 0.58, 0.62, 0.72)	0.598	0.238	4	0.031	22
F_{34}	(0.52, 0.62, 0.66, 0.75)	0.636	0.253	2	0.033	11
F_4						
F_{41}	(0.57, 0.67, 0.71, 0.79)	0.684	0.176	1	0.035	4
F_{42}	(0.52, 0.62, 0.68, 0.78)	0.650	0.167	4	0.034	9
F_{43}	(0.54, 0.64, 0.70, 0.79)	0.667	0.171	2	0.034	5
F_{44}	(0.46, 0.56, 0.61, 0.71)	0.585	0.150	6	0.030	26
F_{45}	(0.54, 0.64, 0.70, 0.77)	0.662	0.170	3	0.034	6
F_{46}	(0.53, 0.63, 0.67, 0.76)	0.649	0.166	5	0.034	10
F_5						
F_{51}	(0.50, 0.60, 0.67, 0.76)	0.633	0.266	1	0.033	12
F_{52}	(0.47, 0.56, 0.62, 0.72)	0.591	0.248	3	0.031	24
F_{53}	(0.40, 0.50, 0.55, 0.65)	0.526	0.221	4	0.027	31
F_{54}	(0.50, 0.60, 0.66, 0.75)	0.629	0.264	2	0.033	14
F_6						
F_{61}	(0.53, 0.63, 0.69, 0.78)	0.659	0.208	2	0.034	7
F_{62}	(0.46, 0.56, 0.62, 0.72)	0.591	0.187	5	0.031	25
F_{63}	(0.50, 0.60, 0.63, 0.73)	0.616	0.195	3	0.032	18
F_{64}	(0.49, 0.59, 0.62, 0.72)	0.603	0.191	4	0.031	20
F_{65}	(0.57, 0.67, 0.73, 0.81)	0.696	0.220	1	0.036	2
F_7						
F_{71}	(0.48, 0.58, 0.63, 0.72)	0.602	0.251	2	0.031	21
F_{72}	(0.51, 0.61, 0.65, 0.74)	0.628	0.262	1	0.032	15
F_{73}	(0.46, 0.55, 0.59, 0.69)	0.572	0.238	4	0.030	28
F_{74}	(0.47, 0.57, 0.63, 0.73)	0.597	0.249	3	0.031	23

The occurrence likelihood calculations were performed based on the same systematic procedure as for the degree of impact. As seen in *Table B.6*, the occurrence likelihood TFN values were calculated using *Equation 11*, as done for the calculation of the TFN values associated with the degree of impact. The likelihood BNP values were obtained using the centroid method, as done for degree of impact, using *Equation 12*. The *Likelihood Ranking*, as shown in *Table B.6*, is the "global ranking" as calculated for degree of impact. The *Degree of Risk*, as seen in *Table B.6*, is the value used for risk ranking. The *Degree of Risk* is obtained by using *Equation 14*, which if re-written is equal to *Equation 16*. The risks are ranked according to the degree of risk.

$$\begin{aligned} &Degree\ of\ Risk \\ &= (Degree\ of\ Risk: Global\ Ranking)(Occurance\ Likelihood: Likelihood\ BNP) \end{aligned} \tag{16}$$

The following table displays the calculations for the occurrence likelihood calculations, also stating the final risk ranking.

Table B.6: Occurrence likelihood and Final Risk Ranking Calculations (Lu, Yu & Chang, 2014)

	Likelihood TFNs	Likelihood BNPs	Likelihood ranking	Degree of risk	Risk ranking
F_1					
F_{11}	(0.53, 0.63, 0.70, 0.79)	0.662	6	0.020	17
F_{12}	(0.51, 0.61, 0.66, 0.76)	0.637	10	0.023	3
F_{13}	(0.67, 0.77, 0.82, 0.90)	0.787	1	0.031	1
F_{14}	(0.51, 0.61, 0.67, 0.76)	0.636	13	0.018	22
F_2					
F_{21}	(0.43, 0.53, 0.57, 0.67)	0.552	30	0.017	27
F_{22}	(0.51, 0.61, 0.66, 0.76)	0.637	11	0.020	14
F_{23}	(0.45, 0.55, 0.62, 0.71)	0.583	24	0.017	29
F_{24}	(0.52, 0.62, 0.68, 0.78)	0.650	8	0.021	9
F_3					
F_{31}	(0.53, 0.63, 0.67, 0.77)	0.650	9	0.022	6
F_{32}	(0.51, 0.61, 0.66, 0.76)	0.637	12	0.020	15
F_{33}	(0.46, 0.56, 0.62, 0.72)	0.591	20	0.018	23
F_{34}	(0.50, 0.60, 0.65, 0.75)	0.624	15	0.021	13
F_4					
F_{41}	(0.47, 0.57, 0.61, 0.71)	0.593	19	0.021	11
F_{42}	(0.55, 0.65, 0.70, 0.80)	0.673	5	0.023	4
F_{43}	(0.57, 0.67, 0.72, 0.81)	0.692	3	0.024	2
F_{44}	(0.44, 0.54, 0.59, 0.69)	0.565	28	0.017	28
F_{45}	(0.43, 0.53, 0.59, 0.69)	0.559	29	0.019	21
F_{46}	(0.48, 0.58, 0.64, 0.74)	0.610	16	0.021	12
F_5					
F_{51}	(0.48, 0.58, 0.63, 0.72)	0.602	18	0.020	16
F_{52}	(0.51, 0.61, 0.67, 0.76)	0.636	14	0.020	18
F_{53}	(0.45, 0.54, 0.61, 0.71)	0.580	25	0.016	31
F_{54}	(0.52, 0.62, 0.69, 0.78)	0.653	7	0.022	8
F_6					
F_{61}	(0.44, 0.54, 0.60, 0.70)	0.572	26	0.019	19
F_{62}	(0.46, 0.56, 0.61, 0.71)	0.585	23	0.018	25
F_{63}	(0.49, 0.59, 0.62, 0.72)	0.604	17	0.019	20
F_{64}	(0.44, 0.54, 0.59, 0.69)	0.565	27	0.018	26
F_{65}	(0.46, 0.56, 0.61, 0.71)	0.585	22	0.021	10
F_7					
F_{71}	(0.61, 0.71, 0.77, 0.85)	0.735	2	0.023	5
F_{72}	(0.56, 0.65, 0.71, 0.80)	0.680	4	0.022	7
F_{73}	(0.43, 0.52, 0.57, 0.67)	0.547	31	0.016	30
F_{74}	(0.47, 0.57, 0.61, 0.71)	0.591	21	0.018	24

APPENDIX C

RISK CHECKLIST AND DESCRIPTIONS

Introduction

The following section aims to present a risk checklist with associated risk descriptions, to be used by potential importers. The checklist will be divided into three categories namely External-, Internal: Local- and Internal: Global Risk, as seen in the graphical representation of the risk breakdown structure. The risk checklist, and descriptions, is a compilation of that researched in *Chapter 5*. The complete risk register is displayed on the following pages.

Table C.1: Risk Register - External Risk

	Risk	Description	Check	Probability	Impact
	Risk Register				
External Risk	***Economic Risk***				
	Inflation	Import inflation refers to the inflation of domestic goods and services as a result of importation. This can be a result of foreign price increases or the depreciation of a country's exchange rate.	☐		
	Changes in relative price/ Price Fluctuation	Price fluctuations refers to the fluctuation of international product prices due to global events, such as oil shortages, new source discovery, and the lifting of country sanctions.	☐		
	Foreign Exchange Rates	Foreign exchange rate fluctuations can be either positive or negative risk, from the view point of a strengthening or depreciating economy. The risk is subject to the contractual obligations of the parties involved, being the exporter, importer and financial institution.	☐		
	Interest Rates	Interest rate refers to the rate at which interest is paid by debtors for money obtained from creditors. An increase in inflation will generally lead to an increased interest rates.	☐		
	Terms of Trade	Terms of trade refers to the ratio between imported- and exported products. Thus, the amount of imported product an economy can afford per unit of exported goods.	☐		
	Taxation on Imported Product	Import taxes are implied on goods imported into South Africa, and is calculated based on the Free on Board value.	☐		
	Political and Social Risk				
	War in exporting country	War in exporting country could lead to shipping delays, or non-delivery of products.	☐		
	Coup d'état	Coup d'état (French terminology) for the sudden overthrow of state.	☐		
	Democratic changes in governme	Democratic changes in government could lead to new legislation surrounding exports, as well as causing instability in the social structure of the exporting country.	☐		
	Other political turmoil	Other political turmoil refers to general political changes which can occur. This includes the sudden change of legislation, or sudden inclusion of new legislation.	☐		
	Price controls	Price controls refers to the implementation of maximum- or minimum price regulations, due to social- or political instability, on goods to be exported.	☐		
	Trade Restrictions	Trade restrictions refers to the implementation of an artificial restriction on the trade of goods between two countries.	☐		
	Nationalization	The risk occurs when privately owned institutions are forced into becoming public owned institutions, resulting in the possibility of sudden change in terms of cost or company policy.	☐		
	Government regulations	The risk occurs when government interferes in a legal manner, resulting in anti-business regulations and laws.	☐		
	Monetary reforms	Monetary reforms refers to any movement that changes the way in which money is supplied, and the economy financed, from the system which is currently implemented in that specific country.	☐		
	Changing social concerns	The risk refers to the concerns of the population towards the export or import of products, in terms of economy well-being, job creation or depreciation, and government state.	☐		
	Riots	Riots can pose a problem in terms of shipment delays, or worst case scenario, product loss.	☐		
	Terrorist movements	Terrorist movements could lead to shipment delays, or worst case scenario, product loss.	☐		
	Government relations	The risk refers to the relationship between the governments of importing- and exporting country. A bad or disintegrating relationship could have an impact on import possibility for both public- and private sector.	☐		
	Technological Change Risk				
	Product innovations	Risk occurs when either a local source, or a competitive source undergoes product innovations. A result of this can be the usage of "old" product, where there might be a better product on the market.	☐		
	Process innovations	Risk occurs when either a local source, or a competitive source undergoes product innovations. A result of this can be that competitor importers receive a better product in a shorter period of time.	☐		
	Innovation by competitors	Risk occurs when competitors find a method for faster, more efficient or cost effective bitumen importation.	☐		
	Force Majeure Risk				
	Hurricanes	Should exporting country be subject to regular hurricane conditions, shipping might be delayed by long periods of time. Worst case scenario could be the loss of product.	☐		
	Earthquakes	Should exporting country be subject to regular earthquake conditions, shipping might be delayed by long periods of time. Worst case scenario could be the complete loss of product.	☐		
	Other natural disasters	Should exporting country be subject to regular occurrence of other natural disasters, shipping might be delayed by long periods of time. Worst case scenario could be a loss of product.	☐		
	Bad weather on open sea	Bad weather at sea could cause shipment delays or even the loss of product.	☐		

Table C.2: Risk Register - Internal Local Risk

Risk Register					
	Risk	**Description**	**Check**	**Probability**	**Impact**
Internal: Local Risk	***Sub-Contractor Risk***				
	Low management competency of sub-contractors	The risk occurs should sub-contractors be used for the unloading of the product upon arrival. If the management skills of the sub-contracting company is not up to standard, unloading delays might occur or even loss of product.	☐		
	Unavailability of skilled sub-contractors	The unavailability of skilled sub-contractors, should sub-contractors be used, could lead to potential loss of product or unloading delays.	☐		
	Lack of coordination between project participants	Sub-contractors and company representatives should work in a systematic and coordinated manner, in order to assure that little time is wasted on disputes. Should an uncoordinated relationship exist, loss of product or unloading delays could realise.	☐		
	Sub-contractor lack of adequate equipment or staff	The importation of bulk volume of bitumen requires large amount of sub-contracting resources. Unavailability of resources can lead to unloading delays.	☐		
	Safety Risk				
	Employee safety risk	When unloading the product, employees may be subject to dangerous conditions such as working with hot bitumen, as well as working in close proximity to water.	☐		
	Labour unrest	Importing bitumen may cause a depreciation in job creation. This, as a result, could lead to labour unrest, causing delays or product loss.	☐		
	Management Risk				
	Unavailability of sufficient professionals and managers	The unavailability of experienced managers could lead to delays as coordination between parties involved could be hindered.	☐		
	Project size and complexity	Should large quantities be imported at once, the project could become more complex, with more parties being involved. This could lead to delays should ineffective coordination and communication exist between parties.	☐		
	Inadequate project management controls	A planned managerial procedure should be in place for successful logistic and product management.	☐		
	Incorrect balance of resources and expertise	Should too little experienced personal be dedicated to the project, coordination may be effected, potentially leading to delays, ineffective logistics management or product loss.	☐		
	Knowledge inadequacy	The use of a project team where little knowledge exist surrounding the import of bitumen could lead to potential logistical mistakes, financial losses, disputes and delays.	☐		

Table C.3: Risk Register - Internal Global Risk

	Risk	Description	Check	Probability	Impact
Internal: Global Risk	***Industry Market Risk***				
	Changes in the quantity used by others	Should more than one importer use the same supplier, with one importer using more than the other, product availability could be affected, resulting in a waiting time for bitumen.	☐		
	Shifts in market supply	Market supply refers to the amount of product to be sold. Should shortages arise, market supply will decrease whilst market demand stay the same. This could lead to waiting periods.	☐		
	Availability of product from other sources	Should available amount from original source decrease, without having additional sources identified as contingency, delays may occur.	☐		
	Scarcity in complimentary products	Should a project require modified bitumen, and complimentary products to modify the bitumen with is scarce, project delays could arise.	☐		
	Rivalry among existing competitors	The addition of rival importers could lead to competition in terms of bitumen prices.	☐		
	New entrants in importing industry	New importers could lead to competition in terms of bitumen prices.	☐		
	Client Risk				
	Design variations by client	Design variations to project bitumen specifications can lead to complications if imported bitumen does not conform.	☐		
	Occurrence of disputes	Should the import project be a public-private partnership, disputes between the clients and importing party may arise. Disputes in a purely private project could also arise, should the client not approve of imported bitumen product.	☐		
	General client generated risk	General client risk refers to client involvement in import process, in terms of logistics management.	☐		
	Client does not allow for adequate time for process	The occurrence of a local bitumen shortage, may result in clients being reluctant to approve of additional time for the import process.	☐		
	Responsibilities of the client team ill defined	The involvement of the client, if responsibilities are ill defined, could lead to disputes.	☐		
	Contractual Risk				
	Product liability uncertainty	Since more than one party is involved when importing bitumen, contracts should clearly state which party carries liability at what stage of the import process.	☐		
	Emissions and pollutants liability uncertainty	Emissions and pollutants liability should be stated in the contract documentation, including who carries the liability at what stage of the import process.	☐		
	Delay in solving contractual issues	Contractual issues can be large source of disputes. Should the disputes not be solved within a given period of time, delays might occur.	☐		
	General legal risks	The risk refers to legal actions that can be taken against the importer should health, safety and environmental laws be ignored or implemented incorrectly. The risk also allows for all legal risk the company can face.	☐		
	Environmental Risk				
	Ecological constraints	Ecological constraints refer to the maximum amount of resources to be gained from the planet. Reaching the limit of constraints could lead to fines, or shortages.	☐		
	Pollution in harbour during unloading	Upon unloading, due to no bitumen specific port in South Africa, external equipment have to be used. This creates an environment where spilling of product, or other forms of pollution, could occur which could lead to fines or delays.	☐		
	Financial Risk				
	Inaccurate cost estimation	Inaccurate cost estimation of the bitumen import system could lead to additional costs.	☐		
	Corrupt practices	Corrupt export-, shipping- or third party corporations could result in poor quality bitumen product, late arrival of bitumen product, non-arrival of product or general financial losses.	☐		
	Fraudulent practices	Fraudulent export-, shipping- or third party corporations could result in poor quality bitumen product, late arrival of bitumen product, non-arrival of product or general financial losses.	☐		
	Inadequate project funding	Should funding for the import process be lacking, additional costs might be incurred.	☐		
	Timing of availability of funds	Late funding from financial institutions could lead to delays, additional costs or contract breaches.	☐		
	No budget for contingency measures	No budget for contingency measures could lead to the importing firm having to pay large monetary sums, using money which is not available at that point in time.	☐		
	Design errors	Project design errors could lead to unusable batch of bitumen being imported resulting in losses or delays.	☐		
	Quantity variations	Should bitumen quantity needed be miscalculated, additional bitumen need to be sourced, resulting in additional costs, delays and sources for more bitumen product.	☐		
	Loss of Cargo	Loss of cargo due to any reason will have financial or time associated implications. Risk ownership is important for such a scenario.	☐		
	Storage Facilities	Inadequate storage facilities could lead to additional facility hire. For large quantities, the additional hire costs will be high.	☐		
	Pre-Contract Risk				
	Unproven design solutions adopted	Unproven design solution refers to solutions implemented to ease the import process or unloading process. Should the solution not work it could cause delays or financial losses.	☐		
	Tendered price	Using imported bitumen is more expensive than locally sourced bitumen. With the tender structure working on a lowest bid process, tenders might not be awarded.	☐		
	Product Quality Risk				
	Product does not confirm to specifications	The non-conformant of the bitumen product, whether at the international refinery or at destination location could have large implications in terms delays and financial losses.	☐		
	Viscosity changes of bitumen during transport	During the transportation section of the import system, bitumen can undergo viscosity changes in terms of hardening and softening.	☐		
	Time Related Risk				
	Unloading delay due to machine failure	Machine failure in the unloading process could cause delays, and as such financial losses.	☐		
	Unsuitable program planning	Unsuitable program planning refer to the shipment and unloading program, which if miss calculated, could further down the process cause delays and financial losses.	☐		
	Excessive approval procedure in administrative government departments	Should the approval of import documentation take longer than expected, delays will occur which could result in contract breach or financial losses.	☐		
	Attainment of correct documentation and permits	The attainment of all the correct documentation takes time. If miss calculated, delays will occur early in the import process.	☐		
	Delay due to labour or equipment productivity	Unproductive labour and inefficient equipment could cause unloading delays, resulting in financial losses.	☐		
	Availability of bitumen specific ports in South Africa	Without bitumen specific ports, external unloading systems will have to constructed. This could lead to potential time delays if not constructed correctly. Furthermore, the construction of the unloading systems will require additional funding.	☐		
	Trade Complience Risk				
	Incomplete approval and other documents	Incomplete documentation could lead to non-approval of import, causing delays and financial losses.	☐		

APPENDIX D

FUZZY LOGIC RISK ASSESSMENT FOR BITUMEN IMPORTATION INTO SOUTH AFRICA

Introduction

The following section shows the RBS, and the fuzzy logic risk assessment as performed on *Microsoft Excel*. The RBS is structured according to *Figure 5.2*. Each risk is given a reference number which stems from the main criteria, stating where the risk sub-criteria, or risk, is placed in the structure. The reference numbers were used as risk identifiers in the fuzzy logic risk assessment. The fuzzy logic risk assessment, as stated previously, is based on the design and implementation methodology as done in the study of Lu *et al.* (2014). For the assessment the participants were referenced as E_1 and E_2, with E_1 representing the *Industry Professional*, and E_2 the *Analyst*. The final risk rank is discussed in *Section 6.4.2*. The RBS and fuzzy logic risk assessment tables are displayed on the following pages.

Risk Breakdown Structures

Table D.1: Risk Breakdown Structure for the Importation of Bitumen into South Africa

Level 0	Level 1	Level 2	Level 3	
Risk Breakdown Structure	F_1 - External Risk	$F_{1.1}$ - Economic Risk	$F_{1.1.1}$	Inflation
			$F_{1.1.2}$	Price Fluctuation
			$F_{1.1.3}$	Foreign Exchange Rates
			$F_{1.1.4}$	Interest rates
			$F_{1.1.5}$	Terms of Trade
			$F_{1.1.6}$	Taxation on Imported Product
		$F_{1.2}$ - Political and Social Risk	$F_{1.2.1}$	War in Exporting Country
			$F_{1.2.2}$	Coup d'état
			$F_{1.2.3}$	Democratic Change in Government
			$F_{1.2.4}$	Other Political Turmoil
			$F_{1.2.5}$	Price Controls
			$F_{1.2.6}$	Trade Restrictions
			$F_{1.2.7}$	Nationalisation
			$F_{1.2.8}$	Government Regulations
			$F_{1.2.9}$	Monetary Reforms
			$F_{1.2.10}$	Changing Social Concerns
			$F_{1.2.11}$	Riots
			$F_{1.2.12}$	Terrorist Movements
			$F_{1.2.13}$	Government Relations
		$F_{1.3}$ - Technological Change Risk	$F_{1.3.1}$	Product Innovations
			$F_{1.3.2}$	Process Innovations
			$F_{1.3.3}$	Innovation by Competitors
		$F_{1.4}$ - Force Majeure Risk	$F_{1.4.1}$	Hurricanes
			$F_{1.4.2}$	Earthquakes
			$F_{1.4.3}$	Other Natural Disasters
			$F_{1.4.4}$	Bad Weather on Open Sea

Level 0	Level 1	Level 2	Level 3	Level 4	
Risk Breakdown Structure	F_2 - Internal Risk	$F_{2.1}$ - Local Risk	$F_{2.1.1}$ - Sub-Contractor Risk	$F_{2.1.1.1}$	Low Management Competency of Sub-Contractors
				$F_{2.1.1.2}$	Unavailability of Skilled Sub-Contractors
				$F_{2.1.1.3}$	Lack of Coordination between Project Participants
				$F_{2.1.1.4}$	Sub-Contractor Lack of Adequate Equipment or Staff
			$F_{2.1.2}$ - Safety Risk	$F_{2.1.2.1}$	Employee Safety Risk
				$F_{2.1.2.2}$	Labour Unrest
			$F_{2.1.3}$ - Management Risk	$F_{2.1.3.1}$	Unavailability of Sufficient Professionals and Managers
				$F_{2.1.3.2}$	Project Size and Complexity
				$F_{2.1.3.3}$	Inadequate Project Management Controls
				$F_{2.1.3.4}$	Incorrect Balance of Resources and Expertise
				$F_{2.1.3.5}$	Knowledge Inadequacy
		$F_{2.2}$ - Global Risk	$F_{2.2.1}$ - Industry Market Risk	$F_{2.2.1.1}$	Changes in the Quantity used by Others
				$F_{2.2.1.2}$	Shifts in Market Supply
				$F_{2.2.1.3}$	Availability of Product from other Sources
				$F_{2.2.1.4}$	Scarcity in Complimentary Products
				$F_{2.2.1.5}$	Rivalry among Existing Competitors
				$F_{2.2.1.6}$	New Entrants in Importing Industry
			$F_{2.2.2}$ - Client Risk	$F_{2.2.2.1}$	Design Variations by Client
				$F_{2.2.2.2}$	Occurrence of Disputes
				$F_{2.2.2.3}$	General Client Generated Risk
				$F_{2.2.2.4}$	Client does not allow Adequate Time for Process
				$F_{2.2.2.5}$	Responsibilities of the Client Team ill Defined
			$F_{2.2.3}$ - Contractual Risk	$F_{2.2.3.1}$	Product liability Uncertainty
				$F_{2.2.3.2}$	Emissions and Pollutants Liability Uncertainty
				$F_{2.2.3.3}$	Delay in Solving Contractual Issues
				$F_{2.2.3.4}$	General Legal Risks
			$F_{2.2.4}$ - Environmental Risk	$F_{2.2.4.1}$	Ecological Constraints
				$F_{2.2.4.2}$	Pollution in Harbour During Unloading
			$F_{2.2.5}$ - Financial Risk	$F_{2.2.5.1}$	Inaccurate Cost Estimation
				$F_{2.2.5.2}$	Corrupt Practices
				$F_{2.2.5.3}$	Fraudulent Practices
				$F_{2.2.5.4}$	Inadequate Project Funding
				$F_{2.2.5.5}$	Timing of Availability of Funds
				$F_{2.2.5.6}$	No Budget for Contingency Measures
				$F_{2.2.5.7}$	Design Errors
				$F_{2.2.5.8}$	Design Quantity Variations
				$F_{2.2.5.9}$	Loss of Cargo
				$F_{2.2.5.10}$	Storage Facilities
			$F_{2.2.6}$ - Pre-Contract Risk	$F_{2.2.6.1}$	Unproven Design Solutions Adopted
				$F_{2.2.6.2}$	Tendered Price
			$F_{2.2.7}$ - Product Quality Risk	$F_{2.2.7.1}$	Product Does not Conform to Specifications
				$F_{2.2.7.2}$	Product Undergoes Viscosity Changes
			$F_{2.2.8}$ - Time Related Risk	$F_{2.2.8.1}$	Unloading Delay due to Machine Failure
				$F_{2.2.8.2}$	Unsuitable Program Planning
				$F_{2.2.8.3}$	Excessive Approval Procedures in Administrative Government Departments
				$F_{2.2.8.4}$	Attainment of Correct Documentation and Permits
				$F_{2.2.8.5}$	Delay due to Labour or Equipment Productivity
				$F_{2.2.8.6}$	Distance from Exporting Country to Importing Country
				$F_{2.2.8.7}$	Availability of Bitumen Specific Ports in South Africa
			$F_{2.2.9}$ - Trade Compliance Risk	$F_{2.2.9.1}$	Incomplete Approval and Other Documentation

Fuzzy Logic Risk Assessment

Table D.2: Fuzzy Logic Degree of Impact Calculations

Degree of Impact Calculations											
Risk Breakdown Structure			Degree of Impact		Impact TFN's				Impact BNP's	Global Weights	Impact Rank
Risk Criteria		Risk	E1	E2							
F_1 - External Risk	$F_{1.1}$ - Economic Risk	$F_{1.1.1}$	S	VUS	0,3	0,4	0,45	0,55	0,425	0,010	65
		$F_{1.1.2}$	A	US	0,3	0,4	0,45	0,55	0,425	0,010	57
		$F_{1.1.3}$	S	US	0,35	0,45	0,55	0,65	0,500	0,012	47
		$F_{1.1.4}$	A	US	0,3	0,4	0,45	0,55	0,425	0,010	57
		$F_{1.1.5}$	US	S	0,35	0,45	0,55	0,65	0,500	0,012	47
		$F_{1.1.6}$	A	US	0,3	0,4	0,45	0,55	0,425	0,010	57
	$F_{1.2}$ - Political and Social Risk	$F_{1.2.1}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{1.2.2}$	US	US	0,2	0,3	0,4	0,5	0,350	0,008	66
		$F_{1.2.3}$	A	US	0,3	0,4	0,45	0,55	0,425	0,010	57
		$F_{1.2.4}$	US	A	0,3	0,4	0,45	0,55	0,425	0,010	57
		$F_{1.2.5}$	A	VUS	0,25	0,35	0,35	0,45	0,350	0,008	70
		$F_{1.2.6}$	US	VUS	0,15	0,25	0,3	0,4	0,275	0,006	72
		$F_{1.2.7}$	US	US	0,2	0,3	0,4	0,5	0,350	0,008	66
		$F_{1.2.8}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{1.2.9}$	US	VS	0,45	0,55	0,6	0,7	0,575	0,014	44
		$F_{1.2.10}$	US	AUS	0,1	0,15	0,25	0,35	0,214	0,005	73
		$F_{1.2.11}$	A	A	0,4	0,5	0,5	0,6	0,500	0,012	53
		$F_{1.2.12}$	A	VS	0,55	0,65	0,65	0,75	0,650	0,015	19
		$F_{1.2.13}$	US	US	0,2	0,3	0,4	0,5	0,350	0,008	66
	$F_{1.3}$ - Technological Change Risk	$F_{1.3.1}$	A	US	0,3	0,4	0,45	0,55	0,425	0,010	57
		$F_{1.3.2}$	US	US	0,2	0,3	0,4	0,5	0,350	0,008	66
		$F_{1.3.3}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
	$F_{1.4}$ - Force Majeure Risk	$F_{1.4.1}$	A	A	0,4	0,5	0,5	0,6	0,500	0,012	53
		$F_{1.4.2}$	A	A	0,4	0,5	0,5	0,6	0,500	0,012	53
		$F_{1.4.3}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{1.4.4}$	S	VS	0,6	0,7	0,75	0,85	0,725	0,017	9
$F_{2.1}$ - Local Risk	$F_{2.1.1}$ - Sub-Contractor Risk	$F_{2.1.1.1}$	S	VS	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.1.1.2}$	S	S	0,5	0,6	0,7	0,8	0,650	0,015	25
		$F_{2.1.1.3}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{2.1.1.4}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
	$F_{2.1.2}$ - Safety Risk	$F_{2.1.2.1}$	S	S	0,5	0,6	0,7	0,8	0,650	0,015	25
		$F_{2.1.2.2}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
	$F_{2.1.3}$ - Management Risk	$F_{2.1.3.1}$	S	VS	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.1.3.2}$	S	S	0,5	0,6	0,7	0,8	0,650	0,015	25
		$F_{2.1.3.3}$	S	VS	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.1.3.4}$	S	A	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{2.1.3.5}$	VS	VS	0,7	0,8	0,8	0,9	0,800	0,019	4
$F_{2.2}$ - Global Risk	$F_{2.2.1}$ - Industry Market Risk	$F_{2.2.1.1}$	S	S	0,5	0,6	0,7	0,8	0,650	0,015	25
		$F_{2.2.1.2}$	S	A	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{2.2.1.3}$	VS	AS	0,75	0,85	0,9	0,95	0,860	0,020	1
		$F_{2.2.1.4}$	A	VS	0,55	0,65	0,65	0,75	0,650	0,015	19
		$F_{2.2.1.5}$	S	US	0,35	0,45	0,55	0,65	0,500	0,012	47
		$F_{2.2.1.6}$	S	US	0,35	0,45	0,55	0,65	0,500	0,012	47
	$F_{2.2.2}$ - Client Risk	$F_{2.2.2.1}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{2.2.2.2}$	VS	S	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.2.2.3}$	US	AUS	0,1	0,15	0,25	0,35	0,214	0,005	73
		$F_{2.2.2.4}$	A	US	0,3	0,4	0,45	0,55	0,425	0,010	57
		$F_{2.2.2.5}$	US	AUS	0,1	0,15	0,25	0,35	0,214	0,005	73
	$F_{2.2.3}$ - Contractual Risk	$F_{2.2.3.1}$	A	AUS	0,2	0,25	0,3	0,4	0,290	0,007	71
		$F_{2.2.3.2}$	US	VS	0,45	0,55	0,6	0,7	0,575	0,014	44
		$F_{2.2.3.3}$	VS	S	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.2.3.4}$	S	S	0,5	0,6	0,7	0,8	0,650	0,015	25
	$F_{2.2.4}$ - Environmental Risk	$F_{2.2.4.1}$	US	S	0,35	0,45	0,55	0,65	0,500	0,012	47
		$F_{2.2.4.2}$	VS	VS	0,7	0,8	0,8	0,9	0,800	0,019	4
	$F_{2.2.5}$ - Financial Risk	$F_{2.2.5.1}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{2.2.5.2}$	VS	VS	0,7	0,8	0,8	0,9	0,800	0,019	4
		$F_{2.2.5.3}$	S	VS	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.2.5.4}$	A	VS	0,55	0,65	0,65	0,75	0,650	0,015	19
		$F_{2.2.5.5}$	VS	A	0,55	0,65	0,65	0,75	0,650	0,015	19
		$F_{2.2.5.6}$	US	S	0,35	0,45	0,55	0,65	0,500	0,012	47
		$F_{2.2.5.7}$	US	A	0,3	0,4	0,45	0,55	0,425	0,010	57
		$F_{2.2.5.8}$	A	A	0,4	0,5	0,5	0,6	0,500	0,012	53
		$F_{2.2.5.9}$	VS	AS	0,75	0,85	0,9	0,95	0,860	0,020	1
		$F_{2.2.5.10}$	S	VS	0,6	0,7	0,75	0,85	0,725	0,017	9
	$F_{2.2.6}$ - Pre-Contract Risk	$F_{2.2.6.1}$	VS	AS	0,75	0,85	0,9	0,95	0,860	0,020	1
		$F_{2.2.6.2}$	US	VS	0,45	0,55	0,6	0,7	0,575	0,014	44
	$F_{2.2.7}$ - Product Quality Risk	$F_{2.2.7.1}$	VS	VS	0,7	0,8	0,8	0,9	0,800	0,019	4
		$F_{2.2.7.2}$	VS	VS	0,7	0,8	0,8	0,9	0,800	0,019	4
	$F_{2.2.8}$ - Time Related Risk	$F_{2.2.8.1}$	VS	S	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.2.8.2}$	A	S	0,45	0,55	0,6	0,7	0,575	0,014	30
		$F_{2.2.8.3}$	VS	A	0,55	0,65	0,65	0,75	0,650	0,015	19
		$F_{2.2.8.4}$	A	VS	0,55	0,65	0,65	0,75	0,650	0,015	19
		$F_{2.2.8.5}$	VS	S	0,6	0,7	0,75	0,85	0,725	0,017	9
		$F_{2.2.8.6}$	S	A	0,45	0,55	0,6	0,7	0,575	0,014	30
	$F_{2.2.9}$ - Trade Complience Risk	$F_{2.2.9.1}$	S	A	0,45	0,55	0,6	0,7	0,575	0,014	0

Table D.3: Fuzzy Logic Occurrence Likelihood Calculations and Risk Ranking

Occurance Likelihood Calculations and Final Risk Ranking													
Risk Breakdown Structure			Occurance Likelihood		Occurance Likelihood TFN's				Likelihood BNP's	Likelihood Rank	Degree of Risk	Risk Rank
Risk Criteria		Risk	E1	E2								
F_1 - External Risk	$F_{1.1}$ - Economic Risk	$F_{1.1.1}$	VL	VL	0,7	0,8	0,8	0,9	0,800	1,000	0,007993	36
		$F_{1.1.2}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,007244	43
		$F_{1.1.3}$	VL	L	0,6	0,7	0,75	0,85	0,725	6,000	0,008522	33
		$F_{1.1.4}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,004246	57
		$F_{1.1.5}$	UL	UL	0,2	0,3	0,4	0,5	0,350	64,000	0,004114	60
		$F_{1.1.6}$	A	VUL	0,25	0,35	0,35	0,45	0,350	69,000	0,003497	68
	$F_{1.2}$ - Political and Social Risk	$F_{1.2.1}$	L	L	0,5	0,6	0,7	0,8	0,650	27,000	0,008786	30
		$F_{1.2.2}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,003497	66
		$F_{1.2.3}$	L	VUL	0,3	0,4	0,45	0,55	0,425	62,000	0,004246	59
		$F_{1.2.4}$	A	L	0,45	0,55	0,6	0,7	0,575	34,000	0,005745	46
		$F_{1.2.5}$	A	A	0,4	0,5	0,5	0,6	0,500	48,000	0,004114	62
		$F_{1.2.6}$	UL	A	0,3	0,4	0,45	0,55	0,425	50,000	0,002748	72
		$F_{1.2.7}$	UL	UL	0,2	0,3	0,4	0,5	0,350	64,000	0,00288	71
		$F_{1.2.8}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,005745	46
		$F_{1.2.9}$	UL	A	0,3	0,4	0,45	0,55	0,425	50,000	0,005745	50
		$F_{1.2.10}$	UL	VUL	0,15	0,25	0,3	0,4	0,275	74,000	0,001385	75
		$F_{1.2.11}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,008522	35
		$F_{1.2.12}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,011078	14
		$F_{1.2.13}$	UL	A	0,3	0,4	0,45	0,55	0,425	50,000	0,003497	66
	$F_{1.3}$ - Technological Change Risk	$F_{1.3.1}$	A	VUL	0,25	0,35	0,35	0,45	0,350	69,000	0,003497	68
		$F_{1.3.2}$	UL	AUL	0,1	0,15	0,25	0,35	0,214	75,000	0,001763	74
		$F_{1.3.3}$	A	VUL	0,25	0,35	0,35	0,45	0,350	69,000	0,004731	55
	$F_{1.4}$ - Force Majeure Risk	$F_{1.4.1}$	A	VUL	0,25	0,35	0,35	0,45	0,350	69,000	0,004114	62
		$F_{1.4.2}$	A	VUL	0,25	0,35	0,35	0,45	0,350	69,000	0,004114	62
		$F_{1.4.3}$	A	L	0,45	0,55	0,6	0,7	0,575	34,000	0,007772	37
		$F_{1.4.4}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,012357	6
$F_{2.1}$ - Local Risk	$F_{2.1.1}$ - Sub-Contractor Risk	$F_{2.1.1.1}$	L	L	0,5	0,6	0,7	0,8	0,650	27,000	0,011078	18
		$F_{2.1.1.2}$	L	L	0,5	0,6	0,7	0,8	0,650	27,000	0,009932	25
		$F_{2.1.1.3}$	A	VL	0,55	0,65	0,65	0,75	0,650	23,000	0,008786	28
		$F_{2.1.1.4}$	A	VL	0,55	0,65	0,65	0,75	0,650	23,000	0,008786	28
	$F_{2.1.2}$ - Safety Risk	$F_{2.1.2.1}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,011078	18
		$F_{2.1.2.2}$	A	L	0,45	0,55	0,6	0,7	0,575	34,000	0,007772	37
	$F_{2.1.3}$ - Management Risk	$F_{2.1.3.1}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,012357	6
		$F_{2.1.3.2}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,011078	18
		$F_{2.1.3.3}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,012357	6
		$F_{2.1.3.4}$	L	A	0,45	0,55	0,6	0,7	0,575	34,000	0,007772	37
		$F_{2.1.3.5}$	L	AL	0,65	0,75	0,85	0,9	0,786	3,000	0,014777	2
$F_{2.2}$ - Global Risk	$F_{2.2.1}$ - Industry Market Risk	$F_{2.2.1.1}$	A	L	0,45	0,55	0,6	0,7	0,575	34,000	0,008786	30
		$F_{2.2.1.2}$	L	L	0,5	0,6	0,7	0,8	0,650	27,000	0,008786	30
		$F_{2.2.1.3}$	L	L	0,5	0,6	0,7	0,8	0,650	27,000	0,013141	5
		$F_{2.2.1.4}$	A	A	0,4	0,5	0,5	0,6	0,500	48,000	0,00764	42
		$F_{2.2.1.5}$	VL	L	0,6	0,7	0,75	0,85	0,725	6,000	0,008522	33
		$F_{2.2.1.6}$	L	VUL	0,3	0,4	0,45	0,55	0,425	62,000	0,004996	53
	$F_{2.2.2}$ - Client Risk	$F_{2.2.2.1}$	UL	UL	0,2	0,3	0,4	0,5	0,350	64,000	0,004731	54
		$F_{2.2.2.2}$	L	L	0,5	0,6	0,7	0,8	0,650	27,000	0,011078	18
		$F_{2.2.2.3}$	A	L	0,45	0,55	0,6	0,7	0,575	34,000	0,002897	70
		$F_{2.2.2.4}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,004246	57
		$F_{2.2.2.5}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,002141	73
	$F_{2.2.3}$ - Contractual Risk	$F_{2.2.3.1}$	L	A	0,45	0,55	0,6	0,7	0,575	34,000	0,00392	65
		$F_{2.2.3.2}$	UL	UL	0,2	0,3	0,4	0,5	0,350	64,000	0,004731	56
		$F_{2.2.3.3}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,012357	6
		$F_{2.2.3.4}$	A	VL	0,55	0,65	0,65	0,75	0,650	23,000	0,009932	24
	$F_{2.2.4}$ - Environmental Risk	$F_{2.2.4.1}$	UL	A	0,3	0,4	0,45	0,55	0,425	50,000	0,004996	51
		$F_{2.2.4.2}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,013635	4
	$F_{2.2.5}$ - Financial Risk	$F_{2.2.5.1}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,005745	46
		$F_{2.2.5.2}$	L	L	0,5	0,6	0,7	0,8	0,650	27,000	0,012224	12
		$F_{2.2.5.3}$	A	L	0,45	0,55	0,6	0,7	0,575	34,000	0,0098	26
		$F_{2.2.5.4}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,006494	45
		$F_{2.2.5.5}$	L	UL	0,35	0,45	0,55	0,65	0,500	45,000	0,00764	41
		$F_{2.2.5.6}$	UL	UL	0,2	0,3	0,4	0,5	0,350	64,000	0,004114	60
		$F_{2.2.5.7}$	L	UL	0,35	0,45	0,55	0,65	0,500	45,000	0,004996	51
		$F_{2.2.5.8}$	L	A	0,45	0,55	0,6	0,7	0,575	34,000	0,006759	44
		$F_{2.2.5.9}$	L	A	0,45	0,55	0,6	0,7	0,575	34,000	0,011625	13
		$F_{2.2.5.10}$	A	VL	0,55	0,65	0,65	0,75	0,650	23,000	0,011078	14
	$F_{2.2.6}$ - Pre-Contract Risk	$F_{2.2.6.1}$	L	UL	0,35	0,45	0,55	0,65	0,500	45,000	0,010109	23
		$F_{2.2.6.2}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,0098	27
	$F_{2.2.7}$ - Product Quality	$F_{2.2.7.1}$	VL	VL	0,7	0,8	0,8	0,9	0,800	1,000	0,015045	1
		$F_{2.2.7.2}$	L	AL	0,65	0,75	0,85	0,9	0,786	3,000	0,014777	2
	$F_{2.2.8}$ - Time Related Risk	$F_{2.2.8.1}$	VL	L	0,6	0,7	0,75	0,85	0,725	6,000	0,012357	6
		$F_{2.2.8.2}$	A	UL	0,3	0,4	0,45	0,55	0,425	50,000	0,005745	46
		$F_{2.2.8.3}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,011078	14
		$F_{2.2.8.4}$	L	VL	0,6	0,7	0,75	0,85	0,725	6,000	0,011078	14
		$F_{2.2.8.5}$	VL	L	0,6	0,7	0,75	0,85	0,725	6,000	0,012357	6
		$F_{2.2.8.6}$	L	AL	0,65	0,75	0,85	0,9	0,786	3,000	0,010621	22
	$F_{2.2.9}$ - Trade Complience Risk	$F_{2.2.9.1}$	A	L	0,45	0,55	0,6	0,7	0,575	34,000	0,007772	37

APPENDIX E

PRICE ADJUSTMENT FACTORS

Introduction

The following section aims to report on the use of PPI based formulae, as well as describing new developments in the field of tender price adjustment. The section first explain the problems surrounding PPI based adjustment formulae. A description of the Bitumen Price Adjustment Factor (BPAF) developed by Mr. Myburgh is then given. The section will conclude with an explanation of the ICA formula, which can be implemented for both locally and internationally sourced bitumen.

Problems with CPI and PPI based Formulae

The current formulae which are used by the South African construction contracts are based on the Haylett equation, which makes use of CPI and PPI indices. The equation was developed specifically for the reimbursement of additional costs acquired in the event of fluctuation in fuel-, material-, plant- and labour costs. The CPAP document states that the formula was developed in order to provide contractors with a clear-cut, agreed upon escalation formula which would ensure the avoidance of disputes and disagreement. The document goes further to state that the CPAP formula was developed to reflect price changes as closely as possible within the boundaries of using an index-based system (Statistics South Africa, 2012).

The CPI and PPI are used to measure the inflation in South Africa. CPI is used to measure the rate of change of the cost of goods and materials bought by consumers, whereas PPI is the measure of change of the prices charged by the producers of goods (Statistics South Africa, 2015). This being said, the factors which influence the pricing of oil based products, especially bitumen, does not just rely on inflation but various other variables. This statement is supported by an article written by W.R. Meadows, a concrete construction company located in the United States of America (W.R. Meadows, 2009).

The Haylett formula uses a weighted method for the final calculations. Should the price of bitumen suddenly rise with a substantial amount, the PPI, as previously mentioned, will still be taken for diesel and furthermore be weighted in correlation with plant-, material- and labour fluctuations. It is however stated in the CPAP document that the formula is not able to precisely reflect the cost fluctuations on a contract (Statistics South Africa, 2012). This leads to potential losses for the contractor, and in some cases the client. Trickey argued that if indices are used in an incorrect manner, due to the wrong index being chosen, it could have a sizable financial impact. The indices may over estimate or underestimate the market conditions as to how the prices of items have changed. For most cases, this will ensure that actual cost fluctuation for bitumen is lower than what was actually spent by the contractor (Ndihokubwayo & Haupt, 2009).

A further problem with the Haylett formula that has been identified is that the formula uses a 0 to 15% value which signifies the risk of price fluctuation that the contractor has to take. According to De Vynck, who did a study on the use of CPAP in a low inflation environment, the 0 to 15% value is incorporated in order to eliminate any escalations in profit. De Vynck goes further to argue to that in a low inflation environment, where there is a decline in profit margins due to the competitiveness of the industry, the 0 to 15% non-adjustable element is in a way penalizing the contractor for profits not really earned (De Vynck, 2002). The Haylett formula is also not usable for imported goods. As such, the instability of the macroeconomic environment creates the need for a price adjustment formula. Little research has been done in the field of price adjustment calculations, thus it is not known to what extend the index based values differ from the real costs associated with the volatile fluctuations of bitumen (Ndihokubwayo & Haupt, 2009).

Developing a Tender Price Adjustment Factor for Bitumen

The need for a tender price adjustment factor which is specifically designed for bitumen prices and which is not based on CPI index values has increased. The CSIR, in conjunction with SABITA, started working on a tender price adjustment factor in 2003. Development of bitumen tender price adjustment factor was undergone as well as the development of a bitumen price index which would have been published by the Statistics South Africa. This research acted as the foundation for the development of the bitumen price adjustment factor (BPAF) in 2012, developed by Mr. Myburgh. The BPAF made use of a correlation between the bitumen list price and other petroleum products.

In 2009 a research team, made up of Ndihokubwayo and Haupt, also started working on a tender price adjustment factor, the aim of which was to determine a formula which would optimise cost escalation recovery. The research design differed from that performed by Mr. Myburgh as the formula was developed not by means of finding a correlation but rather the use of direct- and indirect costs. This following section will describe both price adjustment formulas and how they were developed.

Tender Rate Adjustment Formula Developed by Mr. Myburgh

In 2001, Mr. Myburgh (Myburgh, 2001) started with a project in order to determine a tender price adjustment factor for locally refined bitumen. He proceeded to find a correlation between different fuel prices and the list price of bitumen within South Africa. Mr. Myburgh used the prices of the following oil based products for the comparison:

- Petrol 93 Un-leaded
- Petrol 95 Un-leaded
- Diesel 0.05 Sulphur Content
- Illuminating Paraffin
- Bitumen List Price South Africa

Bitumen list prices were gathered from all the South African refineries, to determine a mean South African list price for bitumen. The list price was the standard price, Rand per ton, which a corporation would have to pay for bitumen from a refinery. Scatter plot graphs were created which represented the list price of bitumen against a certain oil based product, such as illuminating paraffin or diesel, and finding the best fit line for the scatter plot. The decision was made to keep the best fit line linear to ensure that extrapolation and simulations would be simpler and easier to perform. The findings from this model showed that the price of bitumen was best represented by the price of petroleum 95 un-leaded, as it had the highest correlation (R^2) value which was an indication of best fit. When analysing the prices of oil based products which were refined in South Africa, Import and Export Parity Pricing has to be taken into account, as some of the bitumen is further sold off and distributed to various other countries in need. Thus, the South African bitumen market has to be competitive with international refineries.

In order to get an indication of whether or not the prices of South African refined bitumen was competitive in an international market, the mean South African list price of bitumen was compared to the mean free on board (FOB) prices of the countries, Singapore, Thailand and Bahrain. This mean FOB was represented and labelled to be the mean East FOB. It was found that the prices of South African refined bitumen were competitive with the international market, being slightly less expensive. Thus, the same process of creating scatter graphs against South African refined oil products was repeated. This resulted in the closest correlation being between South African refined diesel with 0.05% sulphur content and the mean East FOB. The decision was made my Mr. Myburgh to use the correlation between bitumen list price and diesel 0.05% sulphur content, as it was the most constant for both locally refined and international refined bitumen (Myburgh, 2001). The correlation between the products can be seen in *Figure E.1* and *Figure E.2*.

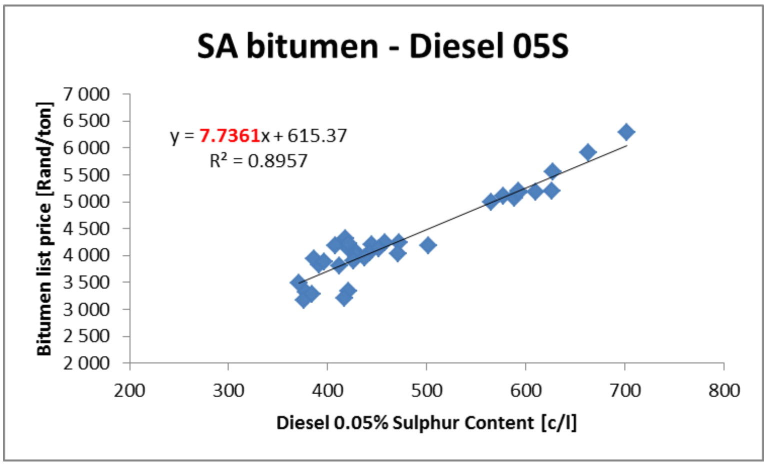

Figure E.1: Mean South African list price and Diesel comparison

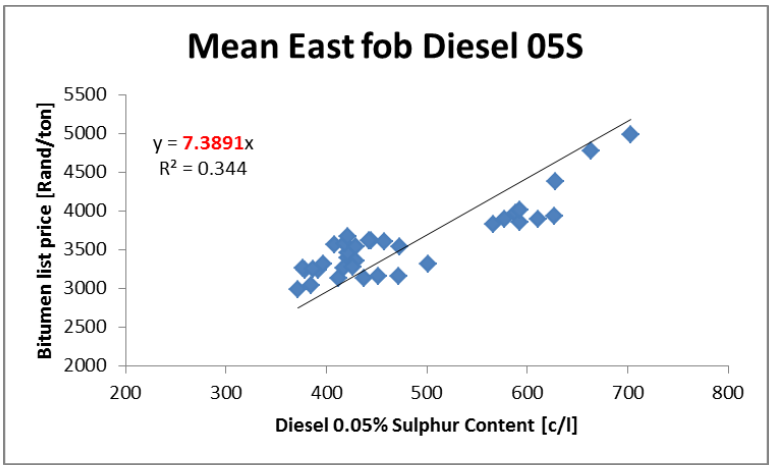

Figure E.2: Mean East FOB price and Diesel comparison

The gradient of the line was used for further simulations for project durations of 3 months, 6 months, 12 months and 24 months. It was gathered for these simulations that the use of the formula would result in reasonable compensation for either the contractor or client, for the rise and fall of the price of bitumen. The aim of this tender rate adjustment factor was to develop a model or formula that could be implemented for any size project, ensuring that reasonable compensation is given. The formula that was produced is displayed below as *Equation 17*.

$$B_j = B_i + 7.7361 \times (BFP_j - BFP_i) \tag{17}$$

B_j	:	Adjusted bitumen tender rate for current month	[R/ton]
B_i	:	Adjusted bitumen tender rate for previous month	[R/ton]
BFP_j	:	Basic Fuel Price of 0.05% Sulphur Diesel for current month	[c/litre]
BFP_i	:	Basic Fuel Price of 0.05% Sulphur Diesel for previous month	[c/litre]

The formula, however, can only be implemented for locally refined bitumen and not for the private importation of bitumen from various international sellers. The reason for this being that the transportation, various freight costs, storage and distribution of the product are not taken into account.

Increased Cost Adjustment (ICA) Formula for Imported Bitumen

The development of the ICA formulae was to counter adverse effects associated with correlation between rising input construction costs and the optimum reimbursement costs regained by contractors. Ndihokubwayo *et al.* (2009) had a two-fold aim for the study, the first being the establishment of shortcomings with current reimbursement formulae, and secondly to introduce an alternative method. The shortcomings of current reimbursement formulae were gathered from academic literature. The ICA formula was developed through a set of assumptions which were derived from a comprehensive breakdown of contract cost (Ndihokubwayo & Haupt, 2009).

The ICA formula was created based on three arguments namely (Ndihokubwayo & Haupt, 2009):

- The formula should take into account that each construction contract is unique;
- The allowable profit margin for a construction project is calculated at the time of tender, thus the profit percentage achieved at the end of the construction project should be close to the estimated allowable profit margin.
- Components of the project sum is effected in differently in terms of losses of the contractor's profit margin.

Taking into account the arguments mentioned above, the ICA formula was created by using a systematic approach, consisting of five assumptions. The ICA formula aims to achieve reconciliation between the profit margin losses and the allowable profit margin. The formula uses actual project costs and implements an adjustment m at each of the interim contract valuation. The assumptions was previously mentioned is based on the *ceteris paribus* assumptions. The contract sum was broken down as follows (Ndihokubwayo & Haupt, 2009):

Table E.1: Breakdown of Contract Sum according to (Ndihokubwayo & Haupt, 2009)

1.	Direct works/costs	X
2.	Preliminaries and General (P&G)	+Y
3.	**Contractor's sum**	**S**
4.	Prime Cost sum	**+Z**
5.	**Sub-total contract sum**	M
6.	Contingencies sum	+O
7.	**Total contract sum**	**N**

Assumption I – Contractor's sum: Direct works (*X*) of versus P&G (*Y*)

The assumption is based on the proportion of direct works to P&G. The larger the amount of direct costs, the smaller the amount of P&G costs. In such a case, the amount recovered through cost adjustment is greater, with the contractor's profit margin being slightly affected. The contractor is able to recovers most of the increased cost on direct works whereas not being able to claim for P&G's, as it is not subject to adjustment.

Assumption II – Contract sum *M*: Contractor's sum *S* versus Prime cost *Z*

The assumptions states that a high contractor's sum results in a low prime cost sum, with little amount being obtained from the prime cost sum and vice versa. It is assumed that if the contractor's sum is lower is due to decrease in resource usage for example, administration costs while revenues from management fees are higher.

Assumption III – Price fluctuation: Cumulative Increased cost *I* versus Cumulative Basic price amount *B*

The assumption states that high price fluctuation affects the profit margin more, and vice versa.

Assumption IV – Allowable profit margin

Each contract has an allowable profit margin

Assumption V – Administration fess: Increased/decreased cost

The assumption allows for costs to be incurred during the process of cost adjustment.

The ICA Formula

By combining all of the above mentioned assumptions, the ICA set of formulas were developed. The set of formulas are displayed by *Table E.2*. This type of domain orientated approach to increased cost escalation adjustment has many advantages. The advantages, according to Ndihokubwayo *et al.*, are as follows (Ndihokubwayo & Haupt, 2009):

- The ICA allows for the auditing of every single item oppose to CPI formulae grouping work in to categories.

- The ICA formula uses actual net increased cost to adjust for price increases, whereas CPI formulae do not attempt to calculate the actual amount of loss involved.
- The ICA formula was developed to incorporate an increased cost adjustment percentage which varies continuously according to the cost increase over the basic amount.

The following table displays the ICA formulae, along with the domains for which they are effective. The domains are in terms of *Direct Cost* and *Preliminaries and General Costs*.

Table E.2: ICA Formulae with associated domains (Ndihokubwayo & Haupt, 2009)

Domain	Form of ICA formula for contract with prime cost sums	Form of ICA formula for contract with no prime cost sums	Equation
$0.80 \leq x \leq 0.95 \; and \; 0.05 \leq y \leq 0.2$	$m = a + \frac{pI(X^2Y - XY^2)}{MBS^2}$	$m = a + \frac{pI(X^2Y - XY^2)}{BS^3}$	(18)
$0.7 \leq x \leq 0.80 \; and \; 0.2 \leq y \leq 0.3$	$m = a + \frac{0.6pIXY}{MBS}$	$m = a + \frac{0.6pIXY}{BS^2}$	(19)
$0.55 \leq x \leq 0.70 \; and \; 0.3 \leq y \leq 0.45$	$m = a + \frac{2pIXY^2}{MBS^2}$	$m = a + \frac{2pIXY^2}{BS^3}$	(20)

Where:

m	Percentage of adjustment (%)
a	Administration fees (%)
p	Allowable profit (%)
I	Cumulative net increased cost of month of valuation
X	Original Direct work/costs
Y	Original Preliminaries and General
M	Sub-total contract sum
B	Cumulative basic price amount in the month of valuation
S	Original Contractor's sum

An example for the implementation of the formulae can be seen in the article written by Ndihokubwayo *et al.* (2009). The study aimed to create formulae with which the shortcomings of current reimbursement formulae could be resolved. The ICA formulae, in comparison to other reimbursement formulae, can be seen in *Table E.3*. According to Ndihokubwayo *et al.* the development of the ICA formulae provides an equitable share of the financial responsibilities between contractor and client, ensuring optimum cost recovery for the contractor (Ndihokubwayo & Haupt, 2009).

Table E.3: Comparison between different cost adjustment formulae (Ndihokubwayo & Haupt, 2009)

	Month 1	Month 2	Month 3	Month 4	Month 5
Original Projected	40 000	120 000	180 000	220 000	250 000
Traditional Method	55 750	148 350	213 600	260 950	300 400
ICA Formula	55 810	148 414	213 660	261 023	300 498
Haylett Formula	56 121	149 017	214 391	261 914	301 356

As seen in the table above, the difference between the ICA formula reimbursement value and that of the currently implemented Haylett formula is on average 678, 80 units. This is not a substantial amount, however, the formula can be used for imported products as it uses no CPI or PPI indices. Furthermore, the traditional method places a financial burden upon the contractor whereas the Haylett formula is stated to place a financial burden on the client. According to the article, the formula does require more extensive implementation, as well as further research into the applicability of the formulae in different fields, such as cost prediction (Ndihokubwayo & Haupt, 2009).

APPENDIX F

CASE STUDY: BITUMEN IMPORTATION

Introduction

The following is a case study to showcase the viscosity changes undergone by bitumen during the import process. The main concern surrounding the importation of bitumen was the viscosity changes, thus the hardening and softening, of bitumen during transit. Not all the shipment's data was available. Only shipment 2, shipment 3, shipment 5 and shipment 7 had data to be analysed. The purpose of this section is to show the hardening or softening of the bitumen during the shipment period. Bitumen specification tests were performed by SGS S.A. at the exporting refinery locations. The following section will show the present the data of each shipment.

Results

Shipment 2 was scheduled in the beginning of 2012. The shipment vessel was the TASCO 1, and transported two types of penetration grade bitumen from Thailand to South Africa. The shipping vessel had four separate storage tanks, three of which contained 50-70 pen bitumen and one 70-100 pen bitumen. The tests performed by SGS prior to departure, as well as the tests done upon arrival at the importers labs are displayed in *Table F.1*. The results show that the 50-70 pen bitumen softened, whilst the 70-100 pen bitumen hardened. The penetration test, in accordance with the ASTM D5-IP49 specification, as well as the softening point test, in accordance with the ASTM D36 specifications, were performed.

Table F.1: Shipment 2 Results

Test Name	Unit	Bitumen Specification	SGS S.A. Results	Importer Lab Results
Penetration Test (ASTM D5-IP49)	25°C	50-70	62	64.9
	100g	50-70	62	63.8
	5s	50-70 (1% Aromatic Oil)	62	57.4
	1/10 mm	70-100	93	81
Softening Point (ASTM D36)	°C	46-56 (50/70 pen.)	48.4	48.1
		46-56 (50/70 pen.)	48.4	47.6

		46-56 (50/70 pen.)	48.4	49.0
		42-51 (70/100 pen.)	43	45.2

Shipment 3 was scheduled in October 2012. The name of the shipment vessel is Stella Virgo. The vessel transported two types of penetration grade bitumen from Dunkirk Refinery, France to South Africa. The tests performed by SGS prior to departure, as well as the tests done upon arrival at the importer's labs are displayed in *Table F.2*. The results show that the 50-70 pen and 70-100 pen bitumen hardened. The penetration test, in accordance with the ASTM D5-IP49 specification, as well as the softening point test, in accordance with the ASTM D36 specifications, were performed.

Table F.2: Shipment 3 Results

Test Name	Unit	Bitumen Specification	SGS S.A. Results	Importer Lab Results
Penetration Test (ASTM D5-IP49)	25°C 100g 5s 1/10 mm	50-70	67	63
		70-100	82	73
Softening Point (ASTM D36)	°C	46-56 (50/70 pen.)	46	49.4
		42-51 (70/100 pen.)	47.8	48.3

Shipment 5 was scheduled in February 2013. The name of the shipment vessel is Stella Orion. The vessel transported two types of penetration grade bitumen from Dunkirk Refinery, France to South Africa. The tests performed by SGS prior to departure, as well as the tests done upon arrival at the importer's labs are displayed in *Table F.3*. The results show that the 50-70 pen and 70-100 pen bitumen softened. The penetration test, in accordance with the ASTM D5-IP49 specification, as well as the softening point test, in accordance with the ASTM D36 specifications, were performed.

Table F.3: Shipment 5 Results

Test Name	Unit	Bitumen Specification	SGS S.A. Results	Importer Lab Results
Penetration Test (ASTM D5-IP49)	25°C 100g 5s 1/10 mm	50-70	63	64
		70-100	90	97
Softening Point (ASTM D36)	°C	46-56 (50/70 pen.)	48	48.6
		42-51 (70/100 pen.)	45.2	45.2

Shipment 7 was scheduled in October 2012. The name of the shipment vessel is Bit Redo. The vessel transported two types of penetration grade bitumen from Dunkirk Refinery, France to South Africa. The tests performed by SGS prior to departure, as well as the tests done upon arrival at the importer's labs are displayed in *Table F.4*. The results show that the 50-70 pen softened, whilst the 70-100 pen bitumen hardened. The penetration test, in accordance with the ASTM D5-IP49 specification, as well as the softening point test, in accordance with the ASTM D36 specifications, were performed.

Table F.4: Shipment 7 Results

Test Name	Unit	Bitumen Specification	SGS S.A. Results	Importer Lab Results
Penetration Test (ASTM D5-IP49)	25°C 100g 5s 1/10 mm	50-70	66	68
		70-100	95	92
Softening Point (ASTM D36)	°C	46-56 (50/70 pen.)	47.8	48.1
		42-51 (70/100 pen.)	45.4	45.2